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DATA ON CHEMICALS FOR CERAMIC USE

FORMULAS, MOLECULAR WEIGHTS, COLORS, CRYSTAL FORMS, DENSITIES, REFRACTIVE INDICES, MELTING POINTS, BOILING POINTS, TRANSITION POINTS, DECOMPOSITION TEMPERATURES

BASED ON

REPORT OF THE COMMITTEE ON CHEMICAL DATA FOR CERAMISTS,
DIVISION OF CHEMISTRY AND CHEMICAL TECHNOLOGY,
NATIONAL RESEARCH COUNCIL

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PREFACE

The data contained in this volume have been taken from the Report of the Committee on Chemical Data for Ceramists which was submitted to the Division of Chemistry and Chemical Technology of the National Research Council, September 1, 1942. The report was published originally in mimeographed form.

Elements and compounds are arranged alphabetically according to names. The original cards from which these data were taken have been filed and are numbered for elements and compounds according to the system employed in the International Critical Tables.

Methods of interpreting the data are indicated in the Introduction which follows.

Grateful acknowledgement is made to various manufacturers in the glass and ceramic fields whose financial support made this investigation possible; also to Dr. Kuan-Han Sun who served as Librarian for the committee.

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TABLES OF CHEMICAL SUBSTANCES AND THEIR PHYSICAL PROPERTIES

INTRODUCTION

This compilation was carried out in two steps:

I. Collection of all available data on density, melting point, transition point, boiling point, sublimation point, decomposition temperature, refractive index, crystal form, and color of chemical substances, to 1941, that are of interest to ceramists. The collection was based on the International Critical Tables (469), the Fifth Edition of the Landolt-Boerntein-Roth-Scheel Physikalische Chemische Tabellen (609, 610, 611, 612), and the Tables de Constants (976) for the period before 1933. Beginning with 1934, the search of the literature was made in Chemical Abstracts. For 1934, 1935, and 1936 formula and subject indexes of Chemical Abstracts were covered line for line to insure the inclusion of pertinent information. It was then observed that all such information was included in sections 2 (general and physical chemistry), 6 (inorganic chemistry), 8 (mineralogical and geological chemistry), 19 (glass, etc.), and 20 (cement, etc.) of Chemical Abstracts. Therefore, from 1937 to 1941 inclusive, the search was carried on by reading the above mentioned sections. Throughout the search, such important works as Gmelin (347, 348), Mellor (675), Pascal (765), Abegg (1), Friend (310), Kelley (518 to 525), Hall and Insley (389, 390), Winchell (1076), Larsen and Berman (617), and Wyckoff (1091, 1092) were consulted. With the exception of a few rare cases, all the original research papers in the period 1934 to 1941 were read by the librarian to insure correct information.

II. The choosing of each property for each substance. This is the final value given in the tables. The choice of the "best" values was based on these considerations: (1) Contents of original papers concerning purity of materials, methods of measurement, accuracy of results, etc. (2) Reliance on investigators and laboratories of prominence. (3) Artificial or synthetic products instead of natural substances, as the latter usually contain impurities which alter the properties. (4) Experimental density rather than density calculated from X-ray data, because small impurities alter the unit cell dimension more than they affect the experimental density. In some cases no density data were available, so they were calculated from X-ray data. Confusion in temperature scales used in the literature has been noted by Wensel (1067). No attempt has been made to correct all temperatures reported in these tables to a unified international temperature scale. It is possible that two substances which have been given the same melting point in these tables may not melt at the same temperature because of different temperature scales used by investigators. For verification, users of these tables should consult original references given in the bibliography which follows the tables.

Data given in these tables are probably the most comprehensive and authoritative to 1941 for the substances listed. Data not listed were not available in the literature. It is hoped that investigators will fill the gaps through their researches.

ARRANGEMENT

The chemical substances are arranged in alphabetical order according to the names. All prefixes are ignored in the arrangement. I. e., sodium chromate will be followed by sodium chromate, bi-, and sodium silicate by sodium silicate, meta-, etc. If several metallic or nonmetallic elements are present in a compound, they are arranged in the order of decreasing electropositivity. For example, $Na_2O \cdot 3CaO \cdot 6SiO_2$ is listed as sodium calcium silicate. Borosilicate, fluosilicate, and phosphosilicate are listed as silicate, boro-, silicate, fluo-, and silicate, phospho-, respectively.

ABBREVIATIONS AND KEY TO TABLES

D	Density. The number at right upper corner of the density value indicates temperature at which the density was measuured in degrees C.; in the absence of such figures room temperature is assumed.
(X-ray)	After density value, indicates that the density was calculated from X-ray data.
M.P.	Melting point in °C. (All temperatures for 760 mm. pressure unless otherwise indicated.)
(incong.)	After melting point, indicates that it is an incongruent melting point.
T.P.	Transition point in °C.
B.P.	Boiling point in °C.
S.P.	Sublimation point in °C.
D.T.	Decomposition temperature in °C.
R.I.	Refractive index or indices, at room temperatures, for the sodium D lines.
e	R.I. for the extraordinary ray.
o	R.I. for the ordinary ray.
g	Greatest R.I.
m	Intermediate R.I.
p	Least R.I.
Nat.	Natural or native. For minerals not preceded by "Nat." part or all of the physical data are for synthetic or artificial types.
I, II, III, etc.	Used after substances, distinguish polymorphic forms. The one with the smallest Roman numeral is the most stable form at high temperatures, and the one with largest Roman numerals is the most stable form at low temperatures (usually room temperature). In the literature the symbolism for polymorphic forms differs and is confusing. Roman numerals (I), (II), (III), etc., in parentheses after names of elements indicate electrovalency; they replace the old "-ous and -ic," etc. (See Rules for Naming Inorganic Compounds – 509 a.)

SUBSTANCES AND PROPERTIES

Aluminum – Al – 26.97 – White – Cubic – D 2.70^{20} (15) – M.P. 660.0 (14) (1026) – B.P. 2056 (15)

Aluminum arsenate, ortho- – $Al_2O_3 \cdot As_2O_5$ – 331.76 – Colorless – Trigonal – D 3.25 (655) – R.I. o 1.596, e 1.607 (655)

Aluminum borate – $Al_2O_3 \cdot B_2O_3$ (Nat. Jeremejevite) – 171.58 – Colorless – Hexagonal – D 3.3 (469) – R.I. o 1.640, e – (469)

Aluminum borate – $3Al_2O_3 \cdot B_2O_3$ – 375.46 – Colorless – Rhombic – D 3.0 (246) – R.I. p 1.586, m. 1.603, g 1.623 (469)

Aluminum carbide – Al_3C_4 – 143.91 – Yellow – Hexagonal – D 2.95 (957) M.P. $>$ 2200 (400 mm.) (881) – R.I. o 2.7, e 2.75 (1075)

Aluminum chloride – Al_2Cl_6 – 266.68 – Colorless – Hexagonal – D 2.44^{25} (469) – M.P. 192.5 (521) – S.P. 180.2 (519)

Aluminum fluoride – AlF_3 – 83.97 – Colorless – Triclinic – D 2.882^{25} (91) – M.P. 1040 (469) – S.P. 1260 (876)

Aluminum fluoride, hydrate – $AlF_3 \cdot H_2O$ (Nat. Fluellite) – 101.99 – Colorless – Rhombic – D 2.17 (469) – R.I. p 1.473, m 1.490, g 1.511 (469)

Aluminum fluoride, hydrate – $2AlF_3 \cdot 5H_2O$ – 258.03 – Colorless – Rhombic – $-5H_2O$ at 300 (737) – R.I. p 1.404, m –, g 1.425 (737)

Aluminum hydroxide – See Aluminum oxide, hydrate

Aluminum nitrate, hydrate – $Al(NO_3)_3 \cdot 9H_2O$ – 375.14 – Colorless – Rhombic – M.P. 73 (469)

Aluminum oxide – Al_2O_3 (I) – 101.94 – Colorless – Hexagonal – D 3.965^{25} (87) – M.P. 2045 (154) – B.P. 2980 (882) – R.I. o 1.768, e 1.760 (702)

Aluminum oxide – Beta-Alumina – Not pure Al_2O_3. See Sodium or Potassium aluminate (838)

Aluminum oxide – Al_2O_3 (III) – 101.94 – Colorless – Cubic – D 3.619 (568) – Transition to I 750-1000 (87) – R.I. 1.696 (702)

Aluminum oxide – Al_2O_3 (Delta) – 101.94 – Colorless – Hexagonal – D 2.40 (763) – Transition to I at 950 (763).

Aluminum oxide – Al_2O_3 (Zeta) – 101.94 – Colorless – Octahedron – D 3.6 (42) – Stable up to 1600 (42) – R.I. 1.736 (Mean) (42)

Aluminum oxide – Al_8O_9 – 359.76 – Yellowish gray – M.P. 2051 (48)

Aluminum oxide, hydrate – $Al_2O_3 \cdot H_2O$ (Boehmite) – 119.96 – Colorless – Rhombic – D 3.014^{20} (305) – D.T. 340 (924) – R.I. p –, m 1.624, g – (2)

Aluminum oxide, hydrate – $Al_2O_3 \cdot H_2O$ (Diaspore) – 119.96 – Colorless – Rhombic – D 3.413 (469) – D.T. 340 (924) – R.I. p 1.702, m 1.722, g 1.750 (469)

Aluminum oxide, hydrate – $Al_2O_3 \cdot 3H_2O$ (Bayerite) – 155.99 – Colorless – D 2.529^{20} (305) – D.T. 120 (305) – R.I. p –, m 1.55, g – (393)

Aluminum oxide, hydrate – $Al_2O_3 \cdot 3H_2O$ (Hydrargillite or Gibbsite) – 155.99 – Colorless – Monoclinic – D 2.424 (305) – D.T. 200 (469) – R.I. p 1.577, m 1.577, g 1.595 (2)

Aluminum phosphate, ortho- – $Al_2O_3 \cdot P_2O_5$ (I) – 243.90 – Colorless – Cubic – R.I. 1.465 (466)

Aluminum phosphate, ortho- – $Al_2O_3 \cdot P_2O_5$ (II) – 243.90 – Colorless – Hexagonal – D 2.560 (466) – Transition to I at 1460 (466) R.I. o 1.524, e 1.530 (466)

Aluminum phosphate, meta- – $Al_2O_3 \cdot 3P_2O_5$ – 527.82 – Colorless – Cubic D 2.71 (415)

Aluminum phosphate, hydrate – $Al_2O_3 \cdot P_2O_5 \cdot 4H_2O$ (Nat. Variscite) – 315.96 – Rhombic – D 2.52 (617) – R.I. p 1.554, m 1.571, g 1.576 (617)

Aluminum phosphate, hydrate – $Al_2O_3 \cdot P_2O_5 \cdot 4H_2O$ (Nat. Metavariscite) – 315.96 – Rhombic – D 2.54 (469) – M.P. > 1500 (469) – p 1.551, m 1.558, g 1.582 (469)

Aluminum phosphate, hydrate – $Al_2O_3 \cdot P_2O_5 \cdot 6H_2O$ (Nat. Lucinite) – 351.99 – Rhombic – D 2.566 (469) – R.I. p 1.563, m 1.585, g 1.592 (469)

Aluminum phosphate, hydrate – $Al_2O_3 \cdot P_2O_5 \cdot 6H_2O$ (Nat. Zepharovicht) – 352.00 – D 2.37 (469) – M.P. > 1500 (469) – R.I. p –, m 1.55, g – (469)

Aluminum phosphate, hydrate – $2Al_2O_3 \cdot P_2O_5 \cdot 3H_2O$ (Nat. Angelite) – 399.89 – Monoclinic – D 2.77 (469) – R.I. p 1.574, m 1.576, g 1.588 (469)

Aluminum phosphate, hydrate – $3Al_2O_3 \cdot P_2O_5 \cdot 18H_2O$ (Nat. Evansite) – 672.05 – Colorless – Amorphous – D 1.94 (617) – R.I. 1.485 (617)

Aluminum phosphate, hydrate – $3Al_2O_3 \cdot 2P_2O_5 \cdot 8H_2O$ (Nat. Sterrettite) – 633.87 – Colorless – Rhombic – D 2.36 (620) – R.I. p 1.572, m 1.590, g 1.601 (620)

Aluminum phosphate, hydrate – $3Al_2O_3 \cdot 2P_2O_5 \cdot 10H_2O$ (Nat. Coeruleolactite) – 669.90 – Colorless – Fiber – D 2.6 ±(617) – R.I. o 1.580, e 1.588 (617)

Aluminum phosphate, hydrate – $3Al_2O_3 \cdot 2P_2O_5 \cdot 13H_2O$ (Nat. Wavellite) – 723.95 – Colorless – Rhombic – D 2.4 (617) – R.I. p 1.525, m 1.534, g 1.552 (617)

Aluminum phosphate, hydrate – $4Al_2O_3 \cdot 3P_2O_5 \cdot 30H_2O$ (Nat. Vashegyite) – 1374.12 – Colorless – Fiber – D 1.96 (617) – R.I. p –, m 1.48, g – (617)

Aluminum phosphate, hydrate – $5Al_2O_3 \cdot 2P_2O_5 \cdot 9H_2O$ (Nat. Spherite) – 955.76 – Rhombic – D 2.536 (469) – R.I. p 1.562, m 1.576, g 1.588 (469)

Aluminum selenide – Al_3Se_4 – 396.75 – M.P. 950 (179)

Aluminum silicate – $Al_2O_3 \cdot SiO_2$ – 162.00 – Colorless – M.P. 1545 (Incong.) (122)

Aluminum silicate – $Al_2O_3 \cdot SiO_2$ (Andalusite) – 162.00 – Colorless – Rhombic – D 3.2 (469) – R.I. p 1.632, m 1.638, g 1.643 (469)

Aluminum silicate – $Al_2O_3 \cdot SiO_2$ (Sillimanite) – 162.00 – Colorless – Rhombic – D 3.247^{25} (299) – Transition to andalusite 1490 (729) – R.I. p 1.659, m 1.660, g 1.680 (617)

Aluminum silicate – $Al_2O_3 \cdot SiO_2$ (Cyanite) – 162.00 – Colorless – Triclinic – D 3.6 (469) – R.I. p 1.712, m 1.720, g 1.728 (469)

Aluminum silicate – $3Al_2O_3 \cdot 2SiO_2$ (Mullite) – 425.94 – Colorless – Rhombic – D 3.156^{25} (469) – M.P. 1830 (Incong.) (947) – R.I. p 1.638, m 1.642, g 1.653 (742)

Aluminum silicate – $3Al_2O_3 \cdot 2SiO_2$ (Glass) – 425.94 – Colorless – D 2.54 (930)

Aluminum silicate, hydrate – $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ (Dickite) – 258.09 – Colorless – Rhombic – D 2.676 (409) – Decomposition starts 500 (1098) – R.I. p 1.561, m 1.563, g 1.566 (1098)

Aluminum silicate, hydrate – $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ (Kaolinite) – 258.09 – Colorless – Monoclinic – D 2.6 (469) – $-2H_2O$ at 450 (923) – R.I. p 1.561, m 1.565, g 1.567 (469)

Aluminum silicate, hydrate – $Al_2O_3 \cdot 2SiO_2 \cdot 4H_2O$ (Nat. Newtonite) – 294.12 – Colorless – Tetragonal – D 2.37 (469) – R.I. o 1.560, e 1.580 (469)

Aluminum silicate, hydrate – $Al_2O_3 \cdot 4SiO_2 \cdot H_2O$ (Nat. Pyrophyllite) – 420.26 – Colorless – Rhombic – D 2.85 (469) – $-H_2O$ at > 600 (923) – R.I. p 1.552, m 1.588, g 1.600 (469)

Aluminum silicate, hydrate – $Al_2O_3 \cdot 6SiO_2 \cdot 18H_2O$ (Nat. Termierite) – 846.65 – Colorless – D 1.21 (1075) – R.I. 1.403 (1075)

Aluminum silicate, hydrate – $2Al_2O_3 \cdot 3SiO_2 \cdot 5H_2O$ (Nat. Kochite) – 474.14 – Colorless – Cubic – D 2.93 (1075) – R.I. 1.590 (1075)

Aluminum silicate, hydrate – $2Al_2O_3 \cdot 6SiO_2 \cdot 3H_2O$ (Nat. Ton) – 618.39 – R.I. 1.53 (317)

Aluminum silicate, hydrate – $2Al_2O_3 \cdot 6SiO_2 \cdot 5H_2O$ (Nat. Anauxite) – 654.42 – Colorless – Monoclinic – R.I. p 1.559, m 1.564, g 1.565 (1075)

Aluminum silicate, hydrate – $2Al_2O_3 \cdot 7SiO_2 \cdot 7H_2O$ (Nat. Takizolite) – 750.41 – R.I. 1.515 (497)

Aluminum silicate, hydrate – $3Al_2O_3 \cdot 8SiO_2 \cdot 7H_2O$ (Nat. Hydrocarbostyril) – 912.41 – R.I. p 1.479, m 1.710, g 1.810 (609)

Aluminum silicate, boro-, hydrate – $8Al_2O_3 \cdot B_2O_3 \cdot 6SiO_2 \cdot H_2O$ – 1263.54 – Rhombic – D 3.3 (469) – R.I. p 1.678, m 1.686, g 1.689 (469)

Aluminum silicate, fluo- – $2AlFO \cdot SiO_2$ (Nat. Topaz) – 184.00 – Rhombic – D 3.58 (469) – R.I. p 1.619, m 1.620, g 1.627 (469)

Aluminum sulfate – $Al_2(SO_4)_3$ – 342.12 – Colorless – D 2.71 (469) – D.T. 757 (760 mm.) (723) – R.I. Mean 1.47 (111)

Aluminum sulfate, hydrate – $Al_2(SO_4)_3 \cdot 18H_2O$ (Alunogenite) – 666.41 – Colorless – Monoclinic – D 1.691^{13} (469) – R.I. p 1.474, m 1.476, g 1.483 (469)

Aluminum sulfide – Al_2S_3 – 150.12 – Yellow – Hexagonal – D 2.02 (469) – M.P. 1100 (469) – S.P. 1550 (in N_2) (469)

Aluminum titanite – $Al_2O_3 \cdot TiO_2$ – 181.84 – M.P. 1860 (156) – R.I. p 1.975, m –, g 2.015 (All for Li-Line) (156)

Ammonia – NH_3 – 17.032 – Colorless gas – D 0.871^{-79} (469) – M.P. —78.0 (984) – B.P. —33.45 (984)

Ammonia, heavy – ND_3 (99% heavy hydrogen) – 20.049 – Colorless gas – D 1.174 (984) – M.P. —74.2 (984) – B.P. —30.9 (984)

Ammonium aluminum sulfate – $(NH_4)_2SO_4 \cdot Al_2(SO_4)_3$ – 474.26 – Colorless – Hexagonal – D 2.45 (899) – D.T. 420-450 (348)

Ammonium arsenate, ortho- – $3(NH_4)_2O \cdot As_2O_5$ – 386.06 – D.T. 100 (879.0 mm.) (665)

Ammonium arsenate, hydrate – $(NH_4)_2O \cdot As_2O_5 \cdot 2H_2O$ – 317.94 – Tetragonal – D 2.340^{20} (665) – R.I. o 1.577, e 1.522 (469)

Ammonium arsenate, hydrate – $2(NH_4)_2O \cdot As_2O_5 \cdot H_2O$ – 352.00 – Monoclinic – D 1.989 (469) – D.T. 149.5 (660.6 mm.) (665)

Ammonium beryllium fluoride – $2NH_4F \cdot BeF_2$ – 121.10 – Rhombic – D 1.683^{30} (826)

Ammonium borate, fluo- – $NH_4F \cdot BF_3$ – 104.86 – Rhombic – D 1.851^{17} (469)

Ammonium borate, hydrate – $(NH_4)_2O \cdot 5B_2O_3 \cdot 8H_2O$ – 542.42 – Colorless – Rhombic – R.I. p 1.490, m 1.431, g 1.436 (348)

Ammonium calcium sulfate – $(NH_4)_2SO_4 \cdot 2CaSO_4$ – 404.42 – Colorless – Cubic – R.I. 1.532 (314)

Ammonium carbonate, bi- – NH_4HCO_3 – 79.06 – Colorless – Rhombic – D 1.586 (609) – M.P. 106 (in capillary tube) (990a) – D.T. 80 (760 mm.) (520) – R.I. p 1.4227, m 1.5358, g 1.5545 (348)

Ammonium chlorate, per- – NH_4ClO_4 (I) – 117.50 – Colorless – Cubic – D 1.73 (X-ray) (421)

Ammonium chlorate, per- – NH_4ClO_4 (II) – 117.50 – Colorless – Rhombic – D 1.9518^{25} (1087) – Transition to I 240 (421) – R.I. p 1.4824, m 1.4828, g 1.4868 (1086)

Ammonium chloride – NH_4Cl (I) – 53.50 – Colorless – Cubic – D 1.265 (X-ray) (46) – M.P. 520 (in capillary tube) (825) – B.P. 340 (132) (943)

Ammonium chloride – NH_4Cl (II) (Salammoniac) – 53.50 – Colorless – Cubic – D 1.5274^{25} (1085) – Transition to I 184.5 (348) – R.I. 1.63851^{25} (1085)

Ammonium chromate – $(NH_4)_2O \cdot CrO_3$ – 152.09 – Yellow – Monoclinic – D 1.89 (609)

Ammonium chromate, di- – $(NH_4)_2O \cdot 2CrO_3$ – 252.10 – Yellowish red – Monoclinic – D 2.15 (469) – T.P. —2.40 (559)

Ammonium fluoride – NH_4F – 37.04 – Colorless – Hexagonal – D 1.0092^{25} (1085) – R.I. o 1.3147, e 1.3160 (1085)

Ammonium hydroxide – NH_4OH – 35.05 – Colorless – Needle – M.P. —79.12 (257)

Ammonium manganate, per- – NH_4MnO_4 – 136.97 – Rhombic – D 2.208^{10} (469) – D.T. 110 (208)

Ammonium molybdate – $(NH_4)_2O \cdot MoO_3$ – 196.03 – Colorless – Monoclinic – D 2.276 (73)

Ammonium nitrate – NH_4NO_3 (I) – 80.05 – Colorless – Cubic – D 1.57 (414) – M.P. 169.6 (469) – D.T. 230 (760 mm.) (440) – R.I. 1.530^{130} (413)

Ammonium nitrate – NH_4NO_3 (II) – 80.05 – Colorless – Tetragonal – D 1.64 (414) – Transition to I 125 (348) – R.I. o 1.509^{93}, e 1.585^{93} (413)

Ammonium nitrate – NH_4NO_3 (III) – 80.05 – Colorless – Rhombic – D 1.66 (414) – Transition to II 83.5 (348) – R.I. p 1.463^{40}, m 1.543^{40}, g 1.600^{40} (413)

Ammonium nitrate – NH_4NO_3 (IV) – 80.05 – Colorless – Rhombic – D 1.714^{32} (197) – Transition to III 32 (348) – R.I. p 1.41, m 1.61, g 1.64 (121)

Ammonium nitrate – NH_4NO_3 (V) – 80.05 – Colorless – Hexagonal – D 1.74 (414) – Transisition to IV —17 (348) – R.I. o 1.493^{-25}, e 1.623^{-25} (413)

Ammonium oxide – $(NH_4)_2O$ – 52.08 – M.P. —78.88 (257)

Ammonium phosphate, meta- – $(NH_4)_2O \cdot P_2O_5$ – 194.12 – Colorless – Monoclinic – D 1.811^{23} (76) – R.I. p 1.490, m –, g 1.505 (536)

Ammonium phosphate, pyro- – $2(NH_4)_2O \cdot P_2O_5$ – 246.20 – Colorless – D 1.543^{18} (76)

Ammonium phosphate, ortho- – $3(NH_4)_2O \cdot P_2O_5$ – 298.28 – Colorless – D 1.480^{-78} (76)

Ammonium phosphate, hydrate – $(NH_4)_2O \cdot P_2O_5 \cdot 2H_2O$ – 230.15 – Colorless – Tetragonal – D 1.798^{25} (76) – T.P. 18.9 (559) – R.I. o 1.525, e 1.479 (469)

Ammonium phosphate, hydrate – $2(NH_4)_2O \cdot P_2O_5 \cdot H_2O$ – 264.22 – Colorless – Monoclinic – D 1.605^{17} (76) – R.I. p –, m 1.52-1.54, g – (348)

Ammonium selenate – $(NH_4)_2O \cdot SeO_3$ – 179.04 – Monoclinic – D 2.194 (469) – R.I. p 1.5607, m 1.5630, g 1.5846 (469)

Ammonium selenate, hydrate – $(NH_4)_2O \cdot 2SeO_3 \cdot H_2O$ – 324.02 – Rhombic – D 2.162 (469)

Ammonium silicate, fluo- – $2NH_4F \cdot SiF_4$ (Cryptohalite) – 178.14 – Cubic – D 2.152 (359) – R.I. 1.370 (469)

Ammonium silicate, fluo- – $2NH_4F \cdot SiF_4$ – 178.14 – Trigonal, Hexagonal – D 2.01 (469) – R.I. o 1.406, e 1.391 (612)

Ammonium sodium phosphate, hydrate – $NH_4NaHPO_4 \cdot 4H_2O$ (Microsmic Salt) – 209.13 – Colorless – Monoclinic – D 1.574 (469) – D.T. 79 (469) – R.I. p 1.439, m 1.442, g 1.469 (469)

Ammonium sulfate – $(NH_4)_2SO_4$ – 132.14 – Colorless – Rhombic – D 1.764 (502) M.P. 513 (528), T.P. 49.71 (559) – R.I. p 1.5209, m 1.5230, g 1.5330 (469)

Ammonium sulfate, bi- – NH_4HSO_4 – 115.11 – Colorless – Rhombic – D 1.78 (469) – M.P. 146.9 (469) – B.P. 490 (469) – R.I. p 1.463, m 1.473, g 1.510 (1075)

Ammonium sulfate, per- – $(NH_4)_2S_2O_8$ – 228.20 – Monoclinic – D 1.982 (469) – D.T. 120 (469) – R.I. p 1.4981, m 1.5016, g 1.5866 (469)

Ammonium sulfide, bi- – NH_4HS – 51.11 – Colorless – Tetragonal – D 1.18 (1071) – R.I. o $>$ 1.74, e $<$ 1.74 (1070)

Ammonium tellurate – $(NH_4)_2O \cdot TeO_3$ – 227.69 – D 3.01 (469)

Ammonium vanadate, meta- – $(NH_4)_2O \cdot V_2O_5$ – 233.98 – D 2.326 (675) – D.T. 200 (241)

Ammonium vanadate, orthothio- – $3(NH_4)_2S \cdot V_2S_5$ – 442.43 – Brown – Rhombic – D 1.620 (595)

Antimony – Sb – 121.76 – Bluish white – Hexagonal – D 6.62^{20} (15) – M.P. 630.5 (14)(1026) – B.P. 1440 (15)

Antimony (III) chloride – $SbCl_3$ – 228.13 – Colorless – Rhombic – D 3.140^{20} (469) – M.P. 72.9 – T.P. 65.0, 69.5 (527) – B.P. 220 (469)

Antimony (V) chloride – $SbCl_5$ – 299.05 – Colorless liquid – D $2.349^{20.9}$ (938) – M.P. 4.0 (521) – B.P. 106.5 (76 mm.) (519) – R.I. 1.601^{14} (469)

Antimony (III) fluoride – SbF_3 – 178.76 – Colorless – Rhombic – D 4.385^{25} (91) – M.P. 292 (469) – B.P. 376 (873)

Antimony (V) fluoride – SbF_5 – 216.76 – Colorless liquid – D 2.99^{23} (469) – M.P. 7 (469) – B.P. 149.5 (469)

Antimony (III, V) fluoride – $2SbF_3 \cdot SbF_5$ – 574.28 – D 4.188^{21} (469) – M.P. 290 (469) – B.P. 390 (469)

Antimony (III) iodide – SbI_3 – 502.52 – Ruby Red – Hexagonal, Rhombic, Monoclinic – D 4.848^{26} (469) – M.P. 170.3 – T.P. 114, 125 (469) – B.P. 401 (469) – R.I. o 2.78, e 2.36 (All for Li line) (1075)

Antimony (V) iodide – SbI_5 – 756.36 – Brown – M.P. 79 (469)

Antimony (III) oxide – Sb_4O_6 (I) (Valentinite) – 583.04 – Colorless – Rhombic – D 5.67 (469) – M.P. 655 (656) – B.P. 1456 (436) – R.I. p 2.18, m 2.35, g 2.35 (469)

Antimony (III) oxide – Sb_4O_6 (II) (Senarmontite) – 583.04 – Colorless – Cubic – D 5.19^{25} (935) – Transition to I 570 (844) – R.I. 2.087 (469)

Antimony (III) oxide – Sb_2O_3 (Glass) – 291.52 – Colorless to slight yellow – D 5.18 + (Quenched sample) (570) – R.I. 2.090 (Quenched sample) (570)

Antimony (V) oxide – Sb_4O_{10} – 583.04 – Yellow – Cubic – D 7.86 (X-ray) (935) – — O at 450 (675)

Antimony (III, V) oxide – $Sb_2O_3 \cdot Sb_2O_5$ (Cervantite) – 615.04 – Colorless – Cubic – D 6.59 (229) – Decomposes to $Sb_2O_3 > 1060$ (675) – R.I. 2.0 (469)

Antimony selenide – SbSe – 200.72 – M.P. 542 (469)

Antimony (III) selenide – Sb_2Se_3 – 480.40 – Gray – M.P. 611 (469)

Antimony (III) sulfate – $Sb_2(SO_4)_3$ – 531.70 – Colorless – Prism – D 3.625^{4} (469)

Antimony (III) sulfide – Sb_4S_6 (Stibenite) – 679.40 – Orange red – Rhombic – D 4.64 (469) – M.P. 546 (521) – R.I. p 3.194, m 4.046, g 4.303 (469)

Antimony (III) sulfide, oxy- – $2Sb_2S_3 \cdot Sb_2O_3$ (Nat. Kermesite) – 970.92 – Cherry red – Monoclinic – D 4.6 (469) – R.I. p 2.74, m –, g – (All for Li-Line) (469)

Antimony (III) telluride – Sb_2Te_3 – 626.35 – Gray – M.P. 629 (469)

Arsenic – As – 74.91 – Steel-gray – Hexagonal – D 5.73^{20} (15) – M.P. 814 (36 Atm.) (14) (1026) – S.P. 615 (15)

Arsenic – As (Glassy) – 74.91 – Silver white – D 4.73 (963)

Arsenic borate – See Boron arsenate

Arsenic (III) chloride – $AsCl_3$ – 181.28 – Colorless liquid – D 2.163^{20} (Liquid) (469) – M.P. —18 (469) – B.P. 130.4 (762 mm.) (92) – R.I. 1.6040 (675)

Arsenic (V) chloride – $AsCl_5$ – 252.19 – Yellow – M.P. —40 (469)

Arsenic (III) fluoride – AsF_3 – 131.91 – Colorless liquid – D 2.666° (469) – M.P. —8.5 (675) – B.P. 64 (873)

Arsenic (V) fluoride – AsF_5 – 169.91 – Colorless gas – M.P. —79.8 (871) – B.P. —52.8 (871)

Arsenic (V) fluoride – AsI_5 – 709.51 – Brown – Monoclinic – D 3.93 (469) – M.P. 70 (675) (609)

Arsenic (III) iodide – AsI_3 – 455.67 – Yellowish red – Hexagonal – D 4.39^{13} (469) – M.P. 141.8 (92) – B.P. 403 (469) – R.I. o 2.59, e 2.23 (6560 A) (1075)

Arsenic (III) oxide – As_4O_6 (Claudetite) – 395.64 – Colorless – Monoclinic – D 3.85-4.15 (617) – M.P. 312.6 – B.P. 457.2 (656) – R.I. p 1.871, m 1.92, g 2.01 (469)

Arsenic (III) oxide – As_4O_6 (Nat. Arsenolite) – 395.64 – Colorless – Cubic – D 3.70 (617) – R.I. 1.755 (617)

Arsenic (III) oxide – As_4O_6("a") – 395.64 – Colorless – Cubic – Metastable M.P. 272.1, Transition to Claudetite 221 (942)

Arsenic (III) oxide – As_4O_6("c") – 395.64 – Colorless – Metastable M.P. 289.6, Claudetite changes to this form at 258.4 (942)

Arsenic (III) oxide – As_2O_3 (Glass) – 197.82 – Colorless or slight yellow – D 3.701 (Quenched sample) (703) – R.I. 1.799 (Quenched sample) (703)

Arsenic (V) oxide – As_4O_{10} – 459.64 – Colorless – D 4.09 (469) – D.T. 400 (675)

Arsenic (III) selenide – As_2Se_3 – 386.70 – Brown – M.P. 260 (347)

Arsenic sulfide – As_4S_3 (Dimorphite) – 395.82 – Yellow – Rhombic – D 3.60^{19} (469) – M.P. > 200 (609)

Arsenic sulfide – As_2S_2(I) (Realgar) – 213.94 – Black – Monoclinic – D 3.254^{19} (469) – M.P. 307 (469) – B.P. 565 (469)

Arsenic sulfide – As_2S_2(II) – 213.94 – Orange red – Monoclinic – D 3.506^{19} (469) – Transition to I 267 (469) – R.I. p 2.538, m 2.684, g 2.704 (617)

Arsenic (III) sulfide – As_2S_3(I) – 246.00 – M.P. 300 (469) – B.P. 707 (469)

Arsenic (III) sulfide – As_2S_3(II) (Orpiment) – 246.00 – Yellow – Monoclinic – D 3.43 (469) – Transition to I 170 (469) – R.I. p 2.4, m 2.81, g 3.02 (All Li line) (617)

Barium – Ba – 137.36 – Silvery white – Cubic – 3.5^{20} (15) – M.P. 704 (14) (1026) – B.P. 1638 (15)

Barium aluminate – $BaO \cdot Al_2O_3$ – 255.30 – White – Cubic, Hexagonal (1043) – D 3.99^{20} (1008) – M.P. 2000 (1052) – R.I. 1.683 (1008)

Barium aluminate – $BaO \cdot 6Al_2O_3$ – 765.00 – Hexagonal – D 3.637^{25} (1012) – M.P. 1860 (1012) – R.I. o 1.702, e 1.694 (1012)

Barium aluminate – $3BaO \cdot Al_2O_3$ – 562.02 – Gray-White – Tabular – D 4.54^{20} (1008) – R.I. m 1.735, $p - g = 0.009$ (1008)

Barium aluminum silicate – $BaO \cdot Al_2O_3 \cdot 2SiO_2$(I) (Celsian) – 375.42 – Hexagonal – D 3.302 (232) – M.P. 1720 (232) – R.I. p 1.5712, m –, g – (232)

Barium aluminum silicate – $BaO \cdot Al_2O_3 \cdot 2SiO_2$(II) (Celsian) – 375.42 – Monoclinic – D 3.37 (469) – R.I. p 1.587, m 1.593, g 1.600 (262)

Barium aluminum silicate – $4BaO \cdot Al_2O_3 \cdot 7SiO_2$ (Nat. Barylite) – 1135.80 – Colorless – Rhombic – D 4.03 (469) – R.I. p 1.681, m 1.685, g 1.695 (469)

Barium arsenate, ortho- – $3BaO \cdot As_2O_5$ – 689.90 – Colorless, transparent – Needle – D 5.10 (378) (380) – M.P. 1605 (378) (380)

Barium arsenate, hydrate – $2BaO \cdot As_2O_5 \cdot 3H_2O$ – 590.58 – Colorless – Rhombic – D 3.93^{18} (469) – R.I. Mean 1.635 (410)

Barium beryllium fluoride – $BaF_2 \cdot BeF_2$ – 222.38 – White – Rhombic – D 4.170^{30} (826) – M.P. 1000 (962)

Barium beryllium fluoride – $BaF_2 \cdot 2BeF_2$ – 269.40 – White – M.P. 900 ± (962)

Barium beryllium silicate – $BaO \cdot 2BeO \cdot 2SiO_2$ (Nat. Barylite) – 323.52 – Colorless – Rhombic – D 4.03 (16) – R.I. p 1.69, m 1.696, g 1.703 (16)

Barium borate – $BaO \cdot B_2O_3$ – 223.00 – Needle – M.P. 1060 (469)

Barium borate – $BaO \cdot 2B_2O_3$ – 292.64 – Needle – M.P. 810 (169)

Barium borate – $BaO \cdot 3B_2O_3$ – 362.28 – M.P. 740 (169)

Barium borate – $BaO \cdot 4B_2O_3$ – 431.92 – M.P. 750 (169)

Barium borate – $2BaO \cdot B_2O_3$ – 376.36 – M.P. 1002 (469)

Barium borate – $3BaO \cdot B_2O_3$ – 529.72 – Colorless – M.P. 1315 (469)

Barium calcium carbonate – $BaCO_3 \cdot CaCO_3$ (Nat. Barytocalcite) – 297.46 – Colorless – Monoclinic – D 3.65 (469) – R.I. p 1.525, m 1.684, g 1.686 (617)

Barium calcium silicate – $BaO \cdot 2CaO \cdot 3SiO_2$ – 445.70 – Colorless – Hexagonal – M.P. 1320 (Incong.) (469) – R.I. o 1.681, e 1.668 (469)

Barium carbonate – $BaCO_3$(I) – 197.37 – White – Regular – D.T. 1421 (760 mm.) (520)

Barium carbonate – $BaCO_3$(II) – 197.37 – White – Hexagonal – Transition to I 982 (469)

Barium carbonate – $BaCO_3$(III) (Witherite) – 197.37 – White – Rhombic – D 4.274 (71) – Transition to II 811 (104) – R.I. p 1.529, m 1.676, g 1.677 (469)

Barium carbonate, oxy- – $BaCO_3 \cdot BaO$ – 350.73 – D.T. 1491 (760 mm.) (520)

Barium cerate – $BaO \cdot CeO_2$ – 325.49 – Cubic – D 6.40 (X-ray) (449)

Barium chlorate – $Ba(ClO_3)_2$ – 304.27 – Colorless – M.P. 414 (469)

Barium chloride – $BaCl_2$(I) – 208.27 – Colorless – Cubic – D 3.917 (1087) – M.P. 960 (521) – B.P. 1560 (469)

Barium chloride – $BaCl_2$(II) – 208.27 – Colorless – Monoclinic – D 3.889 (338) – T.P. 925 (469) – R.I. p 1.73024, m 1.73611, g 1.74196 (1086)

Barium chloride fluoride – BaClF – 191.82 – Colorless – Tetragonal – D 5.931 (469) – M.P. 1008 (469) – R.I. o 1.640, e 1.633 (469)

Barium chloride, oxy- – $BaCl_2 \cdot 2BaO$ – 514.99 – M.P. 995 (Incong.) (727)

Barium chromate – $BaO \cdot CrO_3$ – 253.37 – Yellow – Rhombic – D 4.498^{15} (469)

Barium chromite – $BaO \cdot 4Cr_2O_3$ – 761.44 – Black – Hexagonal – D 5.4 (675)

Barium ferrite – $BaO \cdot Fe_2O_3$ – 313.06 – Hexagonal – M.P. 1390 (25)

Barium fluoride – BaF_2 – 175.36 – Colorless – Cubic – D 4.893^{25} (1087) – M.P. 1287 (521) – B.P. 2260 (876) – R.I. 1.47410 (1086)

Barium formate – $Ba(HCO_2)_2$ – 227.40 – Colorless – Rhombic – D 3.248 (26) – R.I. p 1.567, m 1.587, g 1.627 (26)

Barium hydroxide – See Barium oxide, hydrate

Barium iron (II) silicate – $BaO \cdot FeO \cdot 4SiO_2$ (Gillespite) – 465.45 – Pink – Tetragonal – D 3.33 (469) – R.I. o 1.621, e 1.619 (469)

Barium magnesium fluoride – $BaF_2 \cdot 2MgF_2$ – 300.00 – Colorless – D 4.2 (738) – M.P. 930 (Incong.) (738) – R.I. 1.467 (738)

Barium manganate – $BaO \cdot MnO_3$ – 256.29 – Green – Hexagonal, tabular – D 4.85^{24} (675)

Barium manganite – $BaO \cdot MnO_2$ – 240.29 – D 5.85 (469)

Barium molybdate – $BaO \cdot MoO_3$ – 297.31 – White – Tetragonal – D 4.65 (469) – M.P. 1480 (642)

Barium nickel (IV) oxide – $BaO \cdot 2NiO_2$ – 334.74 – D 4.8 (469)

Barium nitrate – $Ba(NO_3)_2$ – 261.38 – Colorless – Cubic – D 3.232^{25} (1088) – M.P. 595.5 (398) – R.I. 1.5715 (1088)

Barium nitrite – $Ba(NO_2)_2$ – 229.38 – Slight yellow – Hexagonal – D 3.234^{0} (157) – M.P. 267 – T.P. 201, 231 (157) – D.T. 270 (157)

Barium oxalate – BaC_2O_4 – 225.38 – Colorless – D 2.658 (469) D.T. 400 (164)

Barium oxide – BaO – 153.36 – Colorless – Hexagonal or Cubic – D 5.72 (469) – M.P. 1923 (469) – B.P. 2,200 (420) – R.I. Mean 2.08 (684)

Barium oxide, per- – BaO_2 – 169.36 – White – Powder – D 5.43^{25} (62) – D.T. 480 (760 mm.) (1024)

Barium oxide, hydrate – $BaO \cdot H_2O$ – 171.38 – Colorless – Rhombic – D 4.49 (469) – M.P. 325 (293) – D.T. 988 (760 mm.) (469)

Barium oxide, hydrate – $BaO \cdot 2H_2O$ – 189.40 – Colorless – D 3.743 (740)

Barium oxide, hydrate – $BaO \cdot 9H_2O$ – 315.50 – Colorless – Monoclinic – D 2.164 (740) – M.P. 77.9 (469) – R.I. p 1.4710, m 1.5017, g 1.5017 (469)

Barium oxide, per-, hydrate – $BaO_2 \cdot 8H_2O$ – 313.49 – Colorless – Hexagonal – D 2.292 (741) – — $8H_2O$ at 130 (901)

Barium phosphate, meta- – $BaO \cdot P_2O_5$ – 295.32 – White – Crystal – M.P. Red heat (344)

Barium phosphate, pyro- – $2BaO \cdot P_2O_5$ – 448.68 – White – Rhombic, prism – D 3.9 (756)

Barium phosphate, ortho- – $3BaO \cdot P_2O_5$ – 602.04 – Colorless, transparent – Cubic – D 4.1 (469) – M.P. 1727 (1079)

Barium phosphate, chloro- – $3Ba_3(PO_4)_2 \cdot BaCl_2$ – 2014.39 – Colorless – D 5.949 (469) – M.P. 1584 (469) – R.I. o 1.701, e 1.699 (469)

Barium phosphate, fluo- – $3Ba_3(PO_4)_2 \cdot BaF_2$ – 1981.48 – Colorless – Hexagonal – M.P. 1670 (469) – R.I. o 1.669, e 1.665 (469)

Barium phosphate, hydrate – $2BaO \cdot P_2O_5 \cdot H_2O$ – 466.70 – Colorless – Rhombic, prismatic, bipyramid – D 4.165^{15} (469) – R.I. p 1.635, m –, g 1.617 (320)

Barium praseodymium oxide – $BaO \cdot PrO_2$ – 326.28 – Cubic – D 6.52 (X-ray) (449)

Barium selenate – $BaO \cdot SeO_3$ – 280.32 – White – Rhombic – D 4.61 (417)

Barium selenide – BaSe – 216.32 – Cubic – D 5.04 (417) – R.I. 2.268 (384)

Barium silicate – $BaO \cdot SiO_2(I)$ – 213.42 – Colorless – Monoclinic, short rod – D 4.399^{4} (469) – M.P. 1604 (469) – R.I. p 1.673, m 1.674, g 1.678 (469)

Barium silicate – $BaO \cdot SiO_2(II)$ – 213.42 – Colorless – Rhombic – T.P. 1300 + (1084)

Barium silicate – $BaO \cdot SiO_2$ (Glass) – 213.42 – Colorless – D 3.74 (960) – R.I. 1.672 (Extrapolated) (703)

Barium silicate – $BaO \cdot 2SiO_2$ – 273.48 – Colorless – Rhombic – D 3.73 (469) – M.P. 1418 (364) – R.I. p 1.597, m 1.612, g 1.621 (469)

Barium silicate – $BaO \cdot 2SiO_2$ (Glass) – 273.48 – Colorless – R.I. 1.6085 (703)

Barium silicate – $2BaO \cdot SiO_2$ – 366.78 – Colorless – Rounded grain – D 5.2 (1010) – M.P. > 1755 (469) – R.I. p 1.810, m –, g 1.830 (469)

Barium silicate – $2BaO \cdot 3SiO_2$ – 486.90 – Colorless – D 3.93^{4} (469) – M.P. 1450 (469) – R.I. p 1.620, m 1.625, g 1.645 (469)

Barium silicate, fluo- – $BaSiF_6$ – 279.42 – Hexagonal (439) – D 4.279^{15} (469) – D.T. 430 (693 mm.) (395)

Barium silicate, hydrate – $BaO \cdot SiO_2 \cdot 6H_2O$ – 321.52 – Rhombic – D 2.59 (469) – R.I. p 1.542, m 1.548, g 1.548 ± (469)

Barium sulfate – $BaSO_4(I)$ – 233.42 – White – Monoclinic – D 4.499^{15} (469) – M.P. 1350 (521) – R.I. p 1.634, m 1.636, g 1.647 (1075)

Barium sulfate – $BaSO_4(II)$ – 233.42 – White – Rhombic – Transition to I 1149 (469)

Barium sulfide – BaS – 169.42 – Colorless, transparent – Cubic – D 4.25^{15} (469) – M.P. > 1660 (1083) – R.I. 2.155 (384)

Barium tellurate – $BaO \cdot TeO_3$ – 328.97 – White – D 4.48^{16} (469)

Barium telluride – BaTe – 264.97 – Cubic – D 5.51 (384) – R.I. 2.440 (384)

Barium titanium silicate – $BaO \cdot TiO_2 \cdot 3SiO_2$ (Nat. Benitoeite) – 413.44 – Hexagonal – D 3.7 (469) – R.I. o 1.757, e 1.804 (469)

Barium thorate – $BaO \cdot ThO_2$ – 417.48 – Cubic – D 7.66 (X-ray) (449)

Barium tungstate – $BaO \cdot WO_3$ – 385.28 – Colorless – Tetragonal – D 6.35 (469)

Barium vanadate – $2BaO \cdot V_2O_5$ – 488.62 – White, fluoresces in Ultra-violet light – M.P. 863 ± (469)

Barium yttrium silicate, boro- – $BaO \cdot 3Y_2O_3 \cdot 3B_2O_3 \cdot 3SiO_2$ (Nat. Cappelenite) – 1219.98 – Greenish Brown – Hexagonal – D 4.4 (1076) – R.I. o 1.76, e – (1076)

Barium zirconate – $BaO \cdot ZrO_2$ – 276.58 – Cubic – D 6.26 (X-ray) (449) – M.P. 2700 (1055)

Beryllium – Be – 9.02 – Grayish white – Hexagonal – D 1.85^{20} (15) – M.P. 1280 (14) (1026) – B.P. 2780 (15)

Beryllium aluminate – $BeO \cdot Al_2O_3$ (Chrysoberyll) – 126.96 – Colorless – Rhombic – D 3.76 (469) – M.P. 1870 (324) – R.I. p 1.732, m –, g 1.741 (324)

Beryllium aluminum silicate – $3BeO \cdot Al_2O_3 \cdot 6SiO_2$ (Beryl) – 537.36 – Colorless, transparent – Hexagonal – D 2.66 (469) – M.P. 1410 (469) – R.I. o 1.580, e 1.574 (320)

Beryllium aluminum silicate, hydrate – $2BeO \cdot Al_2O_3 \cdot 2SiO_2 \cdot H_2O$ (Nat. Euclase) – 290.12 – Monoclinic – D 3.1 (469) – R.I. p 1.652, m 1.655, g 1.671 (469)

Beryllium aluminum silicate, hydrate – $3BeO \cdot Al_2O_3 \cdot 6SiO_2 \cdot 1/2H_2O$ (Meclov Beryl) – 546.37 – D 2.707 (586) – R.I. o 1.581, e 1.575 (586)

Beryllium borate, hydrate – $4BeO \cdot B_2O_3 \cdot H_2O$ (Nat. Hambergite) – 187.74 – Colorless – Rhombic – D 2.35 (469) – R.I. p 1.560, m 1.591, g 1.631 (469)

Beryllium chloride – $BeCl_2$ – 79.93 – Colorless – Needle – D 1.904^{25} (686) – M.P. 404 – T.P. 300 (900) – B.P. 488 (817)

Beryllium fluoride – BeF_2 (Glass) – 47.02 – Colorless – D 1.986^{25} (91) – Crystalline point 800 ± (630) – R.I. < 1.33 (889)

Beryllium fluoride, oxy- – $5BeF_2 \cdot 2BeO$ – 285.14 – White – D 2.3 (469)

Beryllium germanate – $2BeO \cdot GeO_2$ – 154.64 – Colorless – D 3.868 (904)

Beryllium hydroxide – $Be(OH)_2$ (I, metastable) – 43.04 – White – D 1.920^{20} (305)

Beryllium hydroxide – $Be(OH)_2$ (II, stable) – 43.04 – White – D 1.924^{20} (305)

Beryllium iron (II) yttrium silicate – $2BeO \cdot FeO \cdot Y_2O_3 \cdot 2SiO_2$ (Nat. Gadolinite) – 467.85 – Monoclinic – D 4.3 (469) – R.I. p 1.78 +, m 1.78 +, g 1.785 + (469)

Beryllium lead fluoride – $BeF_2 \cdot PbF_2$ – 292.23 – Colorless – Rhombic – D 6.135^{30} (826)

Beryllium manganese silicate – $BeO \cdot MnO \cdot SiO_2$ (Nat. Trimerite) – 156.01 – Triclinic – D 3.474 (284) – R.I. p 1.715, m 1.720, g 1.725 (284)

Beryllium oxide – BeO – 25.02 – White – Hexagonal – D 3.004 (1073) – M.P. 2520 (1053) – B.P. 3900 (712) – R.I. o 1.719, e 1.733 (469)

Beryllium oxide, per- – BeO_2 – 41.02 – D.T. 18 (760 mm.) (1024)

Beryllium selenate, hydrate – $BeSeO_4 \cdot 4H_2O$ – 224.04 – Colorless – Rhombic – D 2.03 (469) – $-2H_2O$ 103; $-4H_2O$ 300 (932) – R.I. p 1.4664, m 1.5007, g 1.5027 (469)

Beryllium selenide – $BeSe$ – 87.98 – Regular – D 4.315 (X-ray) (1103)

Beryllium silicate – $BeO \cdot SiO_2$ – 85.08 – Colorless – D 2.35 (960) – M.P. > 1755 (469)

Beryllium silicate – $2BeO \cdot SiO_2$ (Phenacite) – 110.10 – Colorless – Triclinic – D 2.985 (904) – M.P. > 2200 (484) – R.I. o 1.654, e 1.668 (691)

Beryllium silicate, hydrate – $4BeO \cdot 2SiO_2 \cdot H_2O$ (Nat. Bertrandite) – 238.22 – Rhombic – D 2.6 (469) – R.I. p 1.591, m 1.605, g 1.614 (469)

Beryllium sulfate – $BeSO_4$ – 105.08 – Colorless – Rhombic – D 2.443 (469) D.T. 790 (760 mm.) (660)

Beryllium sulfide – BeS – 41.08 – Regular – D 2.36 (1100)

Beryllium telluride – $BeTe$ – 136.63 – Gray – Cubic – D 5.09 (X-ray) (1102)

Bismuth – Bi – 209.00 – White – Hexagonal – D 9.80^{20} (15) – M.P. 271.3 (14) (1026) – B.P. 1450 (15)

Bismuth (III) arsenate – $Bi_2O_3 \cdot As_2O_5$ – 695.82 – Colorless – Monoclinic – D 7.14 (469)

Bismuth (III) chloride – $BiCl_3$ – 315.37 – Colorless – D 4.755^{25} (442) – M.P. 224 (521) – B.P. 441 (519)

Bismuth (III) chloride, oxy- – $BiOCl$ – 260.46 – Colorless – Tetragonal – D 7.72 (469) – R.I. o 2.15 (Lambda = 6708Å), e – (41)

Bismuth (III) fluoride – BiF_3 – 266.00 – Colorless or gray – Hexagonal – D 8.35 (401) – M.P. 727 (1048) – R.I. $\substack{o \\ e} > 1.74$ (1048)

Bismuth (V) fluoride – BiF_5 – 304.00 – Rhombic – Sublimation 550 (1048)

Bismuth (III) fluoride, oxy- – $BiFO$ – 244.00 – Colorless – D 7.5 (469)

Bismuth (III) molybdate – $Bi_2O_3 \cdot MoO_3$ (Nat. Koechlinite) – 609.95 – Greenish yellow – Rhombic – R.I. p 2.52, m 2.61, g 2.67 (All Li line) (617)

Bismuth (III) molybdate – $Bi_2O_3 \cdot 3MoO_3$ – 897.85 – Ivory-colored – Tetragonal – D 6.07 (1110) – M.P. 643 (1110)

Bismuth (III) nitrate, hydrate – $Bi(NO_3)_3 \cdot 5H_2O$ – 485.10 – Colorless – Triclinic – D 2.83 (469) – D.T. 30 (469)

Bismuth (III) nitrate, hydrate – $Bi(NO_3)_3 \cdot 6H_2O$ – 503.12 – D 2.76 (469)

Bismuth oxide – BiO – 225.00 – Gray Black – D 7.16 (730)

Bismuth (III) oxide – Bi_2O_3(I) – 466.00 – Yellow – Rhombic – D 8.9 (469) – M.P. 817 (521) – S.P. 1010 (507)

Bismuth (III) oxide – Bi_2O_3(II) – 466.00 – Brown – Cubic – D 8.20 (469) – Transition to I 704 (469)

Bismuth (III) oxide – Bi_2O_3(III) – 466.00 – Light yellow – Rhombic – D 8.5 (469) – M.P. 860 (469) – R.I. 1.91 (348)

Bismuth oxide, di- – BiO_2 – 241.00 – D 5.6 (469)

Bismuth (V) oxide – Bi_2O_5 – 498.00 – Brown – D 5.10 (469) – —O, 250 (348)

Bismuth (III) oxide, hydrate – $Bi_2O_3 \cdot 3H_2O$ (Nat. Bismite) – 520.04 – Colorless – Rhombic – D 4.962^{15} (730) – D.T. 415 (469) R.I. o 2.01, e 1.82 (469)

Bismuth (V) oxide, hydrate – $Bi_2O_5 \cdot H_2O$ – 516.02 – Yellowish white – D 5.75 (469) – D.T. 120 (469)

Bismuth (III) phosphate – $Bi_2O_3 \cdot P_2O_5$ – 607.96 – Colorless – Monoclinic – D 6.323^{15} (907)

Bismuth selenide – BiSe – 287.96 – D 7.98 (X-ray) (762) – M.P. 625 (469) – T.P. 422 (348)

Bismuth (III) selenide – Bi_2Se_3 (Guanajuatite) – 654.88 – Silver white – Rhombic – D 6.82 (469) – M.P. 710 (469)

Bismuth (III) silicate – $Bi_2O_3 \cdot SiO_2$ – 526.06 – Yellowish brown – D 8.92^{20} (755) – M.P. 770-890 (755)

Bismuth (III) silicate – $Bi_2O_3 \cdot 2SiO_2$ – 586.12 – D 8.66^{20} (755) – M.P. 873 (755)

Bismuth (III) silicate – $Bi_2O_3 \cdot 3SiO_2$ – 646.18 – Yellowish brown – D 8.11^{20} (755) – M.P. 847 (755)

Bismuth (III) silicate – $Bi_2O_3 \cdot 8SiO_2$ – 946.48 – Gray – Rhombic – D 6.62^{20} (755) – M.P. 992 (755)

Bismuth (III) silicate – $2Bi_2O_3 \cdot SiO_2$ – 992.06 – Yellowish brown – D 9.14^{20} (755) – M.P. 820 (755)

Bismuth (III) silicate – $2Bi_2O_3 \cdot 3SiO_2$ – 1112.18 – D 8.984^{20} (755) – M.P. 860 (755)

Bismuth (III) silicate – $2Bi_2O_3 \cdot 3SiO_2$ (Nat. Agricolite) – 1112.18 – Yellow – Monoclinic – D 6 (469) – R.I. p –, m 1.99, g – (469)

Bismuth (III) silicate – $2Bi_2O_3 \cdot 3SiO_2$ (Nat. Eulytite) – 1112.18 – Yellow – Cubic – D 6.11 (469) – R.I. 2.05 (469)

Bismuth (III) silicate – $3Bi_2O_3 \cdot SiO_2$ – 1458.06 – Brownish green – D 8.90^{20} (755) – M.P. 822 (755)

Bismuth (III) silicate – $3Bi_2O_3 \cdot 2SiO_2$ – 1518.12 – Brown – Prism – D 8.39^{20} (755) – M.P. 790 (755)

Bismuth (III) silicate – $10Bi_2O_3 \cdot SiO_2$ – 4720.06 – D 9.14^{20} (755) – M.P. 832 (755)

Bismuth (III) sulfate – $Bi_2(SO_4)_3$ – 706.18 – Colorless – Needles – D 5.08^{15} (53)

Bismuth sulfide – BiS – 241.06 – Gray –D 7.7 (469) – M.P. 685 (469)

Bismuth (III) sulfide – Bi_2S_3 (Bismuthinite) – 514.18 – Brownish black – D 7.39 (469) – M.P. 747 (521)

Bismuth (III) telluride – Bi_2Te_3 (Tetradymite) – 800.83 – Gray – Rhombohedral – D 7.81 (777) – M.P. 573 (469)

Bismuth (III) tungstate – $Bi_2O_3 \cdot 3WO_3$ – 1161.76 – Greenish white – Monoclinic – D 8.24^{8} (1110) – M.P. 832 (1110)

Bismuth (III) vanadate – $Bi_2O_3 \cdot V_2O_5$ (Nat. Pucherite) – 647.90 – Reddish brown – Rhombic – D 6.25^{25} (469) – R.I. p 2.41, m 2.50, g 2.51 (All for Li-Line) (469)

Boric acid – See Boron oxide, hydrate

Boron – B – 10.82 – Hexagonal – D 2.3 (15) – M.P. 2300 (14) (1026) – B.P. 2550 (15)

Boron arsenate – $B_2O_3 \cdot As_2O_5$ – 299.46 – Tetragonal – D 3.642 (909) – R.I. o 1.681, e 1.690 (911)

Boron chloride – BCl_3 – 117.19 – Colorless gas – D 1.3493^{11} (136) – M.P. —107 (469) – S.P. 12.5 (519) – R.I. $1.4195^{5.7}$ (Alpha line of hydrogen) (332)

Boron fluoride – BF_3 – 67.82 – Colorless gas – D 1.68^{-128} (Liquid) (283) 1.98^{-188} (Solid) (632) – M.P. —128 (521) – B.P. —100.9 (519)

Boron fluoride, hydrate – $B_2O_3 \cdot 4HF \cdot H_2O$ – 167.70 – Colorless liquid – D 1.657^{25} (953) – B.P. 159.1 (745 mm.) (953) – R.I. 1.3414^{30} (953)

Boron oxide – BO – 26.82 – Brown and transparent (1127)

Boron oxide – B_2O_3 – 69.64 – Colorless – Rhombohedra – D 2.460 (583) – M.P. 450 (583) – B.P. 1860 (calc.) (203) – R.I. o 1.648, e 1.615 (583)

Boron oxide – B_2O_3 (Glass) – 69.64 – Colorless – D 1.812 (703) – R.I. 1.458 (703)

Boron oxide, hydrate – $B_2O_3 \cdot H_2O$(I) – 87.66 – Colorless – Rhombic Dodecahedra – D 2.486 (583) – M.P. 236 (583) – R.I. 1.619 (583)

Boron oxide, hydrate – $B_2O_3 \cdot H_2O$(II) – 87.66 – Colorless – Monoclinic – D 2.044 (583) – M.P. 200.9 (583) – R.I. p 1.434, m 1.570, g 1.588 (583)

Boron oxide, hydrate – $B_2O_3 \cdot H_2O$(III) – 87.66 – Colorless – Rhombic – D 1.78 (583) – M.P. 176.0 (583) – R.I. $p < 1.376$, m 1.514, g 1.521 (583)

Boron oxide, hydrate – $B_2O_3 \cdot 3H_2O$ (Sassolite) – 123.68 – Colorless – Triclinic – D. 1.49 (469) – M.P. 170.9 (583) – R.I. p 1.337, m 1.461, g 1.462 (583)

Boron phosphate – $B_2O_3 \cdot P_2O_5$ – 211.60 – Colorless – Tetragonal – D 2.802 (X-ray) (909) – R.I. o 1.595, e 1.601 (909)

Boron sulfide – B_2S_3 – 117.82 – Colorless – Vitreous or Needle – D 1.55 (348) – M.P. 310 (348)

Bromine – Br (Br_2) – 79.916 – Deep red liquid – D 3.12^{20} (15) – M.P. −7.2 (14) (1026) – B.P. 58.78 (15)

Cadmium – Cd – 112.41 – Bluish white – Hexagonal – D 8.65^{20} (15) – M.P. 320.9 (14) (1026) – B.P. 767.0 (15)

Cadmium antimonate – $2CdO \cdot Sb_2O_5$ – 680.34 – Pale yellow – Cubic – D 6.5 (X-ray) (35)

Cadmium arsenate – $2CdO \cdot As_2O_5$ – 586.64 – Yellowish white – Rhombic – D 5.474^{15} (906)

Cadmium borate – $CdO \cdot B_2O_3$ – 198.05 – M.P. 875 (469)

Cadmium carbonate – $CdCO_3$ – 172.42 – Triclinic – D 4.258 (469) – D.T. 344 (760 mm.) (520)

Cadmium chloride – $CdCl_2$ – 183.32 – Colorless – Cubic – D 4.047^{25} (469) – M.P. 568 (469) – S.P. 962.9 (519)

Cadmium chromite – $CdO \cdot Cr_2O_3$ – 280.43 – Black – Cubic – D 5.79^{17} (1032)

Cadmium chromium sulfide – $CdS \cdot Cr_2S_3$ – 344.67 – Cubic – D 4.295 (X-ray) (770)

Cadmium columbate – $CdO \cdot Cb_2O_5$ – 394.23 – D 5.93^{17} (675)

Cadmium ferrite – $CdO \cdot Fe_2O_3$ – 288.09 – Cubic – D 5.764 (798) – M.P. 1540 (25) – R.I. 2.39 (Li-line) (612)

Cadmium fluoride – CdF_2 – 150.41 – White – Cubic – D 6.64 (469) – M.P. 1110 (521) – B.P. 1748 (876)

Cadmium formate – $Cd(HCO_2)_2$ – 202.45 – Colorless – Rhombic – D 3.297 (26) – R.I. p 1.588, m 1.607, g 1.685 (26)

Cadmium hydroxide – $Cd(OH)_2$ – 146.43 – Colorless – Trigonal – D 4.810^{25} (460) – D.T. 300 (469)

Cadmium indium oxide – $CdO \cdot In_2O_3$ – 405.93 – White – Tetragonal – D 7.30 (768)

Cadmium molybdate – $CdO \cdot MoO_3$ – 271.46 – Yellow – Plates - D 5.347 (X-ray) (348)

Cadmium nitrate – $Cd(NO_3)_2$ – 236.43 – M.P. 350 (469)

Cadmium nitrate, hydrate – $Cd(NO_3)_2 \cdot 4H_2O$ – 308.49 – Colorless – Prism or Needle – D 2.455^{19} (469) – M.P. 59.4 (469) – B.P. 132 (469)

Cadmium oxalate – CdC_2O_4 – 200.43 – D 3.32^{18} (469) – D.T. 340 (469)

Cadmium oxide, sub- – Cd_2O – 240.82 – Green – D 8.192^{18} (469)

Cadmium oxide – CdO – 128.41 – Brown – Cubic – D 8.15 (469) – S.P. 1559 (519) – R.I. 2.49 (Li line) (612)

Cadmium phosphate, pyro- – $2CdO \cdot P_2O_5$ – 398.86 – White – Long leaflet – D 4.965^{15} (906)

Cadmium phosphate, ortho- – $3CdO \cdot P_2O_5$ – 527.27 – Colorless – M.P. 1500 (469)

Cadmium phosphate, hydrate – $CdO \cdot P_2O_5 \cdot 4H_2O$ – 342.51 – Colorless – Trigonal – D 2.742^{15} (469) – D.T. 100 (469)

Cadmium phosphate, hydrate – $2CdO \cdot P_2O_5 \cdot 2H_2O$ – 434.89 – White – D 4.965^{15} (469) – M.P. 900 (469)

Cadmium phosphate, hydrate – $5CdO \cdot 2P_2O_5 \cdot 5H_2O$ – 1016.21 – Colorless – Monoclinic – D 4.13^{15} (469) – D.T. 550 (469)

Cadmium phosphate chloride – $3Cd_3(PO_4)_2 \cdot CdCl_2$ – 1765.13 – D 5.46^{15} (469)

Cadmium selenate, hydrate – $CdO \cdot SeO_3 \cdot 2H_2O$ – 291.40 – Rhombic – D 3.632 (469) – $-2H_2O$ at 170 (539)

Cadmium selenide – CdSe – 191.37 – Gold yellow or gray – Hexagonal – D 5.81^{15} (469) – M.P. 1350 (180)

Cadmium selenite – $CdO \cdot SeO_2$ – 239.37 – Yellowish white – Rhombic

Cadmium selenite – $CdO \cdot 2SeO_2$ – 350.33 – Yellow – Rhombic

Cadmium silicate – $CdO \cdot SiO_2$ – 188.47 – Colorless – Rhombic – D 4.93 (469) – M.P. 1242 (469) – R.I. $^{o}_{e} > 1.739$ (486)

Cadmium silicate – $2CdO \cdot SiO_2$ – 316.88 – D 5.833^{25} (89) – M.P. 1247 (486) – R.I. $^{o}_{e} > 1.739$ (486)

Cadmium sulfate – $CdSO_4$ – 208.47 – White – Rhombic – D 4.691^{24} (469) – M.P. 1000 (469)

Cadmium sulfate, hydrate – $CdSO_4 \cdot H_2O$ – 226.49 – Monoclinic – D 3.786 (469) – T.P. 74.5 (60)

Cadmium sulfate, hydrate – $CdSO_4 \cdot 7H_2O$ – 334.58 – Colorless – Monoclinic – D 2.48 (469) – T.P. 4 (469)

Cadmium sulfide – CdS (Greenockite) – 144.47 – Yellow or red – Hexagonal – D 4.820 (469) – M.P. 1750 (100 atm.) (469) – Sublimation begins at 980 (66) – R.I. o 2.506, e 2.529 (469)

Cadmium telluride – CdTe – 240.02 – Black – Cubic – D 6.20^{15} (469) – M.P. 1041 (469)

Cadmium titanate – $CdO \cdot TiO_2$(I) – 208.31 – Cubic

Cadmium titanate – $CdO\cdot TiO_2$(II) – 208.31 – Rhombic – D 6.5 (X-ray) (1106) – Transition to I 1050 (802)

Calcium – Ca – 40.08 – Yellowish white – Cubic – D 1.55^{20} (15) – M.P. 850 (14) (1026) – B.P. 1487 (15)

Calcium aluminate – $CaO\cdot Al_2O_3$ – 158.02 – Colorless – Monoclinic, Rhombic, or Triclinic – D 2.981^{25} (930) – M.P. 1600 (469) – R.I. p 1.643, m 1.655, g 1.663 (469)

Calcium aluminate – $CaO\cdot 2Al_2O_3$ – 259.96 – Colorless – Monoclinic – D 2.90 (604) – M.P. 1765 (Incong.) (982)

Calcium aluminate – $CaO\cdot 6Al_2O_3$ – 667.72 – Hexagonal – D 3.38 (1012) – R.I. o 1.702, e 1.667 (1012)

Calcium aluminate – $3CaO\cdot Al_2O_3$ – 270.18 – Colorless – Cubic – D 3.00 (604) – M.P. 1535 (Incong.) (469) – R.I. 1.710 (469)

Calcium aluminate – $3CaO\cdot 5Al_2O_3$(I) – 677.94 – Recent formulation $CaO\cdot 2Al_2O_3$ (982) – Rhombic – M.P. 1720 (469) – R.I. p 1.662, m 1.671, g 1.674 (930)

Calcium aluminate – $3CaO\cdot 5Al_2O_3$(II) – 677.94 – Tetragonal – R.I. o 1.617, e 1.652 (469)

Calcium aluminate – $3CaO\cdot 16Al_2O_3$ – 1595.40 – Colorless – Hexagonal – D 3.93 (X-ray) (604) (972)

Calcium aluminate – $5CaO\cdot 3Al_2O_3$ – 586.22 – Recent formulation $12CaO\cdot 7Al_2O_3$ (151) (999)

Calcium aluminate – $5CaO\cdot 3Al_2O_3$ (Glass) – 586.22 – R.I. 1.662 (930)

Calcium aluminate – $12CaO\cdot 7Al_2O_3$(I) – 2386.54 – Yellow – Rhombic – R.I. p 1.687, m –, g 1.692 (824)

Calcium aluminate – $12CaO\cdot 7Al_2O_3$(II) – 2386.54 – Yellow – Cubic – D 2.69 (151) – T.P. 1150-1200 (245) – M.P. 1455 (469) – R.I. 1.608 (469)

Calcium aluminate – $12CaO\cdot 7Al_2O_3$ (Glass) – 2386.54 – D $>$ 2.87 (151) – R.I. $>$ that of the corresponding crystal (151)

Calcium aluminate, hydrate – $3CaO\cdot Al_2O_3\cdot 6H_2O$ – 378.28 – Colorless – Cubic – D 2.522^{20} (998) – $-4H_2O$ at 275-450, $-6H_2O$ at 1000 (1014) – R.I. 1.604 (997)

Calcium aluminate, hydrate – $3CaO\cdot Al_2O_3\cdot 8H_2O$ – 414.31 – Colorless – Hexagonal – D 2.130^{20} (998) – R.I. o 1.538, e 1.520 (998)

Calcium aluminate, hydrate – $3CaO\cdot Al_2O_3\cdot 12H_2O$ – 486.37 – Colorless – Hexagonal – R.I. o 1.527, e 1.503 (998)

Calcium aluminate, hydrate – $4CaO\cdot Al_2O_3\cdot 12H_2O$ – 542.45 – Colorless – R.I. o 1.532, e 1.505 (1064)

Calcium aluminate, hydrate – $4CaO\cdot Al_2O_3\cdot 13H_2O$ – 560.47 – Colorless – R.I. o 1.533, e 1.522 (717)

Calcium aluminate, hydrate – $6CaO\cdot 2Al_2O_3\cdot 21H_2O$ – 918.69 – Colorless – D 2.038^{20} (998) – R.I. o 1.530, e 1.510 (998)

Calcium aluminate, hydrate – $8CaO\cdot 2Al_2O_3\cdot 27H_2O$ – 1138.95 – Colorless – R.I. o 1.535, e 1.512 (29)

Calcium aluminum manganese (III) silicate – $2CaO\cdot Al_2O_3\cdot Mn_2O_3\cdot 4SiO_2$ (Nat. Tinzenite) – 612.20 – Yellow – Monoclinic – D 3.29 (617) – R.I. p 1.693, m 1.701, g 1.704 (617)

Calcium aluminum phosphate, hydrate – $CaO\cdot 2Al_2O_3\cdot P_2O_5\cdot 5H_2O$ (Nat. Crandallite) – 492.08 – Rhombic – D 3.5 (469) – R.I. o 1.595, e 1.585 (469)

Calcium aluminum phosphate, hydrate – $5CaO\cdot 6Al_2O_3\cdot 4P_2O_5\cdot 18H_2O$ (Nat. Pseudowavellite) – 1784.65 – Trigonal – D 2.9 (617) – R.I. o 1.622, e 1.631 (617)

Calcium aluminum phosphate, hydrate – $6CaO\cdot Al_2O_3\cdot 2P_2O_5\cdot 5H_2O$ (Nat. Dennisonite) – 812.66 – Colorless – Hexagonal – D 2.85 (617) – R.I. o 1.601, e 1.591 (617)

Calcium aluminum phosphate, hydrate – $8CaO\cdot 5Al_2O_3\cdot 4P_2O_5\cdot 14H_2O$ (Nat. Deltaite) – 1778.89 – Colorless – Trigonal – D 2.95 (617) – R.I. o 1.630, e 1.640 (617)

Calcium aluminum silicate – $CaO\cdot Al_2O_3\cdot 2SiO_2$ (Anorthite) – 278.14 – Colorless – Triclinic – D 2.765 (469) – M.P. 1550 (469) – R.I. p 1.576, m 1.584, g 1.588 (469)

Calcium aluminum silicate – $CaO\cdot Al_2O_3\cdot 2SiO_2$ (Glass) – 278.14 – Colorless – D 2.700 (221) – R.I. 1.5755 (615)

Calcium aluminum silicate – $2CaO\cdot Al_2O_3\cdot SiO_2$ (Gehlenite) – 274.16 – Colorless – Tetragonal – D 3.038 (273) – M.P. 1590 (469) R.I. o 1.669, e 1.658 (469)

Calcium aluminum silicate – $2CaO\cdot Al_2O_3\cdot SiO_2$ (Glass) – 274.16 – Colorless – D 2.884 (273) – R.I. 1.638 (273)

Calcium aluminum silicate – $2CaO\cdot 3Al_2O_3\cdot 9SiO_2$ (Nat. Didymolite) – 958.52 – Monoclinic – D 2.71 (469) – R.I. p –, m 1.501, g (469)

Calcium aluminum silicate – $3CaO\cdot Al_2O_3\cdot SiO_2$ – 330.24 – Colorless – Rhombic – M.P. 1335 (Incong.) (824) – R.I. p 1.675, m –, g 1.685 (469)

Calcium aluminum silicate – $3CaO\cdot Al_2O_3\cdot 3SiO_2$ (Nat. Grossularite) – 450.36 – Colorless – Cubic – D 3.530 (469) – M.P. 1180 (1118) – R.I. 1.735 (469)

Calcium aluminum silicate – $4CaO\cdot 3Al_2O_3\cdot 6SiO_2$ (Nat. Meionite) – 890.50 – Tetragonal – D 2.74 (469) – R.I. o 1.597, e 1.560 (469)

Calcium aluminum silicate, hydrate – $CaO\cdot Al_2O_3\cdot 2SiO_2\cdot 2H_2O$ (Nat. Hibschite) – 314.17 – Cubic – D 3.05 (469) – R.I. 1.67 (469)

Calcium aluminum silicate, hydrate – $CaO\cdot Al_2O_3\cdot 2SiO_2\cdot 2H_2O$ (Nat. Lawsonite) – 314.17 – Rhombic – D 3.09 (469) – R.I. p 1.665, m 1.674, g 1.684 (469)

Calcium aluminum silicate, hydrate – $CaO\cdot Al_2O_3\cdot 3SiO_2\cdot 2H_2O$ (Nat. Scolecite) – 374.23 – Colorless – Monoclinic – D 2.274^{20} (428) – R.I. p 1.513, m 1.520, g 1.521 (428)

Calcium aluminum silicate, hydrate – $CaO\cdot Al_2O_3\cdot 3SiO_2\cdot 5H_2O$ (Nat. Levy-nite) – 428.28 – Trigonal – D 2.1 (469) – R.I. o 1.496, e 1.491 (469)

Calcium aluminum silicate, hydrate – $CaO\cdot Al_2O_3\cdot 4SiO_2\cdot 4H_2O$ (Nat. Laumontite) – 470.32 – Monoclinic – D 2.3 (469) – R.I. p 1.513, m 1.524, g 1.525 (469)

Calcium aluminum silicate, hydrate – $CaO\cdot Al_2O_3\cdot 4SiO_2\cdot 4H_2O$ (Nat. Gismondite) – 470.32 – Colorless – Monoclinic – D 2.27 (617) – R.I. p –, m 1.539, g – (469)

Calcium aluminum silicate, hydrate – $CaO\cdot Al_2O_3\cdot 6SiO_2\cdot 5H_2O$ (Nat. Epistilbite) – 608.46 – Monoclinic – D 2.25 (469) – R.I. p 1.502, m 1.510, g 1.512 (469)

Calcium aluminum silicate, hydrate – $CaO\cdot Al_2O_3\cdot 6SiO_2\cdot 5H_2O$ (Nat. Heulandite) – 608.46 – Monoclinic – D 2.2 (469) – R.I. p 1.498, m 1.499, g 1.505 (469)

Calcium aluminum silicate, hydrate – $CaO\cdot Al_2O_3\cdot 7SiO_2\cdot 7H_2O$ (Nat. Stellerite) – 704.55 – Rhombic – D 2.12 (469) – R.I. p 1.484, m 1.492, g 1.495 (469)

Calcium aluminum silicate, hydrate – $CaO\cdot 2Al_2O_3\cdot 2SiO_2\cdot H_2O$ (Nat. Margarite) – 296.16 – Monoclinic – D 3.0 (469) – R.I. p 1.632, m 1.643, g 1.645 (469)

Calcium aluminum silicate, hydrate – $2CaO\cdot Al_2O_3\cdot 3SiO_2\cdot H_2O$ – 412.30 – Rhombic – D 2.9 (469) – R.I. p 1.616, m 1.626, g 1.649 (469)

Calcium aluminum silicate, hydrate – $2CaO\cdot Al_2O_3\cdot 5SiO_2\cdot 6H_2O$ (Nat. Laubanite) – 622.50 – Monoclinic – D 2.2 (469) – R.I. o 1.475, e 1.486 (469)

Calcium aluminum silicate, hydrate – $3CaO\cdot Al_2O_3\cdot 2SiO_2\cdot 2H_2O$ (Nat. Plazolite) – 426.33 – Cubic – D 3.55 (759)

Calcium aluminum silicate, hydrate – $3CaO\cdot Al_2O_3\cdot 6SiO_2\cdot H_2O$ (Nat. Bavenite) – 648.55 – Monoclinic – D 2.72 (469) – R.I. p 1.578, m 1.579, g 1.583 (469)

Calcium aluminum silicate, hydrate – $4CaO\cdot Al_2O_3\cdot 4SiO_2\cdot H_2O$ (Nat. Vesuvianite) – 584.51 – Tetragonal – D 3.36 (617) – R.I. o 1.719, e 1.715 (617)

Calcium aluminum silicate, hydrate – $4CaO\cdot 3Al_2O_3\cdot 6SiO_2\cdot H_2O$ (Nat. Zoisite) – 908.52 – Rhombic – D 3.3 (469) – R.I. p 1.700, m 1.702, g 1.706 (469)

Calcium aluminum silicate, hydrate – $4CaO\cdot 3Al_2O_3\cdot 6SiO_2\cdot H_2O$ (Nat. Clinozoisite) – 908.52 – Monoclinic – D 3.36 (469) – R.I. p 1.724, m 1.729, g 1.734 (469)

Calcium aluminum silicate, hydrate – $6CaO\cdot 3Al_2O_3\cdot 7SiO_2\cdot 4H_2O$ (Nat. Pumpellyite) – 1134.79 – Monoclinic – D 3.2 (617) – R.I. p 1.700, m 1.700, m 1.707, g 1.718 (617)

Calcium antimonate, pyro- – $2CaO\cdot Sb_2O_5$ – 435.68 – Yellow – Cubic – D 4.8 (X-ray) (35)

Calcium arsenate, ortho- – $3CaO\cdot As_2O_5$ – 398.06 – Colorless – D 3.620 (378) – M.P. 1455 (378)

Calcium arsenate, hydrate – $2CaO\cdot As_2O_5\cdot H_2O$ – 360.00 – Plates – R.I. p 1.625, m –, g 1.655 (828)

Calcium arsenate, hydrate – $2CaO\cdot As_2O_5\cdot 3H_2O$ (Nat. Haidingerite) – 396.03 – Colorless – Rhombic – D 2.967 (469) – R.I. p 1.590, m 1.602, g 1.638 (469)

Calcium arsenate, hydrate – $2CaO\cdot As_2O_5\cdot 5H_2O$ (Nat. Pharmacolite) – 432.06 – Colorless – Monoclinic – D 2.754 (617) – R.I. p 1.583, m 1.589, g 1.594 (469)

Calcium arsenate, hydrate – $2CaO\cdot As_2O_5\cdot 8H_2O$ (Nat. Wapplerite) – 486.11 – Colorless – Triclinic – D 2.48 (469) – R.I. p 1.525, m 1.537, g 1.552 (469)

Calcium arsenate, hydrate – $3CaO\cdot As_2O_5\cdot 2H_2O$ – 434.10 – Monoclinic – R.I. p –, m 1.615, g 1.62 (828)

Calcium arsenate, hydrate – $5CaO\cdot 2As_2O_5\cdot 6H_2O$ – 848.15 – R.I. p –, m 1.60, g 1.64 (828)

Calcium beryllium aluminum silicate, hydrate – $4CaO\cdot BeO\cdot Al_2O_3\cdot 9SiO_2\cdot H_2O$ (Nat. Bavenite) – 909.84 – Colorless – Rhombic – D 2.745 (601) – R.I. p 1.583, m 1.585, g 1.590 (601)

Calcium beryllium fluoride – $CaF_2\cdot BeF_2$ – 125.10 – Colorless – Rhombic – D 2.959^{30} (826)

Calcium beryllium phosphate, hydrate – $2CaO\cdot 2BeO\cdot P_2O_5\cdot H_2O$ (Nat. Hydroherderite) – 322.26 – Colorless – Rhombic – D 3.00 (469) – R.I. p 1.592, m 1.612, g 1.621 (469)

Calcium borate – $CaO\cdot B_2O_3$ – 125.72 – Colorless – Rhombic – M.P. 1154 (170) – R.I. p 1.550, m 1.660, g 1.680 (170)

Calcium borate – $CaO \cdot 2B_2O_3$ – 195.36 – Colorless – Rhombic – M.P. 986 (170) – R.I. o 1.638, e 1.568 (170)

Calcium borate – $2CaO \cdot B_2O_3$ – 181.80 – Grains – M.P. 1298 (170) – R.I. p 1.585, m 1.662, g 1.667 (170)

Calcium borate – $3CaO \cdot B_2O_3$ – 237.88 – Colorless – Prism – M.P. 1479 (170) – R.I. o 1.728, e 1.630 (170)

Calcium borate, hydrate – $CaO \cdot B_2O_3 \cdot 6H_2O$ – 233.82 – Colorless – Tetragonal – D 1.88 (778) – R.I. o 1.520, e 1.502 (678)

Calcium borate, hydrate – $CaO \cdot 3B_2O_3 \cdot 4H_2O$ – 337.06 – R.I. p 1.505, m –, g 1.550 (736)

Calcium borate, hydrate – $2CaO \cdot 3B_2O_3 \cdot 2H_2O$ (Nat. Veatchite) – 357.11 – Colorless – Monoclinic – D 2.69 (974) – R.I. p 1.551, m 1.553, g 1.621 (974)

Calcium borate, hydrate – $2CaO \cdot 3B_2O_3 \cdot 5H_2O$ (Nat. Colemanite) – 411.16 – Colorless – Monoclinic – D 2.43 (469) – R.I. p 1.586, m 1.592, g 1.614 (469)

Calcium borate, hydrate – $2CaO \cdot 3B_2O_3 \cdot 7H_2O$ (Nat. Meyerhofferite) – 447.19 – Colorless – Triclinic – D 2.12 (469) – R.I. p 1.500, m 1.535, g 1.560 (469)

Calcium borate, hydrate – $2CaO \cdot 3B_2O_3 \cdot 9H_2O$ – 483.22 – Colorless – R.I. p 1.505, m –, g 1.523 (678)

Calcium borate, hydrate – $2CaO \cdot 3B_2O_3 \cdot 13H_2O$ (Nat. Inyoite) – 555.28 – Colorless – Monoclinic – D 1.875 (469) – R.I. p. 1.492, m 1.505, g 1.516 (110)

Calcium borate, hydrate – $2CaO \cdot 7B_2O_3 \cdot 8H_2O$ (Nat. Ginorite) – 278.56 – Monoclinic – R.I. p 1.517, m 1.524, g 1.577 (213)

Calcium borate, hydrate – $5CaO \cdot 6B_2O_3 \cdot 9H_2O$ (Nat. Priceite) – 860.38 – Colorless – Triclinic – D 2.4 (469) – R.I. p 1.572, m 1.591, g 1.594 (469)

Calcium borate, hydrate – $8CaO \cdot 10B_2O_3 \cdot 15H_2O$ (Nat. Pandermite) – 1415.28 – Colorless – Triclinic – D 2.43 (469) – R.I. p 1.582, m 1.592, $g < 1.606$ (469)

Calcium borate, fluo- – $CaF_2 \cdot 2BF_3$ – 213.72 – Rhombic – R.I. p –, m –, $g < 1.26$ (227)

Calcium carbide – CaC_2 – 64.10 – Greenish yellow – Rhombic – D 2.22 (469) – M.P. 2300 (469) – R.I. $p > 1.75$, m –, g – (1045)

Calcium carbide, oxy- – $CaO \cdot CaC_2$ – 120.18 – M.P. 1980 (289)

Calcium carbonate – $CaCO_3$ – 100.09 – Colorless – D 2.72^{20} (591) – M.P. 1282 (Under its own equilibrium pressure) (521) – D.T. 894.4 (760 mm.) (952)

Calcium carbonate – $CaCO_3$ (Aragonite) – 100.09 – Colorless – Rhombic – D 2.930 (20) – Transition to calcite 520 (1122) – R.I. p 1.5299, m 1.6809, g 1.6854 (469)

Calcium carbonate – $CaCO_3$ (Calcite) – 100.09 – Colorless – Rhombic, Hexagonal – D 2.71032^{18} (291) – M.P. 1339 (1025 atm.) (469) – T.P. 970 (Under CO_2 pressure) (103) – D.T. 898.6 (469) – R.I. o 1.6583, e 1.4864 (469)

Calcium carbonate – $CaCO_3$ (Vaterite) – See Calcite or $\mu CaCO_3$ – (335)

Calcium carbonate – $\mu CaCO_3$ – 100.09 – Colorless – Hexagonal – D 2.54 (503) – R.I. o 1.550, e 1.650 (503)

Calcium carbonate, bi- – $Ca(HCO_3)_2$ – 162.12 – Colorless – Rhombic – D 2.015 (469) – R.I. p 1.5101, m 1.5135, g 1.5775 (469)

Calcium carbonate, hydrate – $CaCO_3 \cdot H_2O$ – 118.11 – Colorless – D 1.992^{20} (591)

Calcium carbonate, hydrate – $CaCO_3 \cdot 5H_2O$ – 190.17 – Colorless – D 1.830^{15} (464)

Calcium carbonate, hydrate – $CaCO_3 \cdot 6H_2O$ – 208.19 – Colorless – Monoclinic – D 1.771^{0} (591) – R.I. p 1.460, m 1.535, g 1.545 (469)

Calcium carbonate phosphate – $CaCO_3 \cdot 2Ca_3(PO_4)_2$ (Nat. Dahllite) – 720.65 – Colorless – Hexagonal – D 3.08 (469) – D.T. 1470 (253) – R.I. o 1.635, e 1.631 (469)

Calcium carbonate phosphate – $CaCO_3 \cdot 3Ca_3(PO_4)_2$ (Podolite) – 1030.93 – Colorless – Hexagonal – D 3.08 (469) – R.I. o 1.635, e 1.626 (254)

Calcium chloride – $CaCl_2$ (Hydrophilite) – 110.99 – Colorless – Rhombic and pseudo-tetragonal – D 2.1741^{25} (338) – M.P. 782 (521) – B.P. > 1600 (469) – R.I. p 1.600, m 1.605, g 1.613 (939)

Calcium chloride fluoride – $CaClF$ – 94.54 – Colorless – D 3.07 (469) – D.T. 737 (469)

Calcium chloride, hydrate – $CaCl_2 \cdot 4H_2O$ – 183.06 – Colorless – D 1.826 (1089) – R.I. p 1.548, m –, g 1.566 (1089)

Calcium chloride, hydrate – $CaCl_2 \cdot 6H_2O$ – 219.09 – Colorless – Hexagonal – D 1.7121 (1089) – R.I. o 1.5504, e 1.4949 (1089)

Calcium chloride, oxy- – $CaO \cdot 4CaCl_2$ – 500.04 – M.P 839 (727) – T.P. 700 (727)

Calcium chromate – $CaO \cdot CrO_3$ – 156.09 – Tetragonal – D 3.22 (X-ray) (192) – D.T. 1125 (31)

Calcium chromite – $CaO \cdot Cr_2O_3$ – 208.10 – Green – Rhombic – D 4.8 (469) – M.P. 2170 (1053) – R.I. o 2.33, e 2.18 (1029)

Calcium chromite – $2CaO \cdot Cr_2O_3$ – 264.18 – Green – R.I. p 2.20, m –, g 2.29 (1028)

Calcium chromite – $3CaO\cdot Cr_2O_3$ – 320.26 – R.I. o 1.950, e 1.923 (1029)

Calcium chromium (III) silicate – $3CaO\cdot Cr_2O_3\cdot 3SiO_2$ (Nat. Uvarovite) – 500.44 – Green – Cubic – D 3.42 (469) – R.I. 1.838 (469)

Calcium columbate – $2CaO\cdot Cb_2O_5$ – 377.98 – Colorless – Prismatic – D 4.48 (675)

Calcium copper (II) silicate – $CaO\cdot CuO\cdot 4SiO_2$ (Egyptian Blue) – 375.89 – Blue – Tetragonal – D 2.95 (628) – R.I. o 1.635, e 1.605 (628)

Calcium fluoride – CaF_2 (Nat. Fluorite) – 78.8 – Colorless – Cubic – D 3.180^{20} (469) – M.P. 1392 (521) – B.P. 2500 (876) – R.I. 1.4339 (469)

Calcium formate – $Ca(HCO_2)_2$ – 130.12 – Colorless – Rhombic – D 2.014 (26) – R.I. p 1.510, m 1.514, g 1.574 (26)

Calcium hydroxide – $Ca(OH)_2$ – 74.10 – Colorless – Hexagonal – D 2.230 (27) – —H_2O 525 (337) – R.I. o 1.574, e 1.545 (27)

Calcium indium oxide – $CaO\cdot In_2O_3$ – 333.60 – Colorless – Tetragonal – D 5.87 (X-ray) (768)

Calcium iron (III) aluminate – $4CaO\cdot Fe_2O_3\cdot Al_2O_3$ – 485.94 – Brown – Rhombic – D 3.77 (394) – M.P. 1418 (988) – R.I. p 1.98, m 2.05, g 2.08 (All for lambda = 5780 Å) (394)

Calcium iron (II) carbonate – $CaFe(CO_3)_2$ (Nat. Ferrodolomite) – 215.94 – Trigonal – R.I. o 1.741, e 1.536 (295)

Calcium iron (II) oxide – $CaO\cdot 9FeO$ – 702.64 – M.P. 1310 (663)

Calcium iron (III) oxide – $CaO\cdot Fe_2O_3$ – 215.76 – Reddish brown – Trigonal, Tetragonal – D 5.08 (719) – M.P. 1216 (Incong.) (469) – R.I. o 2.58, e 2.43 (469)

Calcium iron (III) oxide – $2CaO\cdot Fe_2O_3$ – 271.84 – Light brown – Tabular – D 3.98 (719) – M.P. 1436 (Incong.) (469) – R.I. p 2.200, m 2.200, g 2.290 (All for Li line) (469)

Calcium iron (III) oxide – $3CaO\cdot Fe_2O_3$ – 327.92 – Deep ruby red – Monoclinic – R.I. p –, m $>$ 1.73, g – (276)

Calcium iron (II,III) oxide – $4CaO\cdot 3Fe_3O_4$ – 918.88 – Needle – M.P. 1200 (663)

Calcium iron (III) oxide, hydrate – $3CaO\cdot Fe_2O_3\cdot 6H_2O$ – 436.02 – Cubic – D 2.77 (249) – D.T. 210 (286) – R.I. 1.710 (249)

Calcium iron (III) oxide, hydrate – $3CaO\cdot Fe_2O_3\cdot 6H_2O$ – 436.02 – Hexagonal – R.I. 1.61-1.66 (249)

Calcium iron (II) silicate – $CaO\cdot FeO\cdot SiO_2$ – 187.98 – Rhombic – M.P. 1208 (129) – R.I. p 1.6958, m 1.7340, g 1.7430 (452)

Calcium iron (II) silicate – $CaO\cdot FeO\cdot 2SiO_2$ (Hendenbergite) – 248.04 – Monoclinic – D 3.53 (795) – M.P. 1100 (469) – T.P. 965 (130) – R.I. p 1.726, m 1.735, g 1.752 (1077)

Calcium iron (II) silicate – $2CaO\cdot FeO\cdot 2SiO_2$ (Nat. Ferroakermanite) 304.12 – R.I. o 1.670, e 1.658 (452)

Calcium iron (III) silicate – $3CaO\cdot Fe_2O_3\cdot 3SiO_2$ – 508.10 – Cubic – D 3.793^{19} (81) – M.P. About 1100 (348) – R.I. 1.9 (611)

Calcium lanthanum silicate – $CaO\cdot La_2O_3\cdot 2SiO_2$ – 502.04 – Colorless – Hexagonal – R.I. o 1.880, e 1.874 (256)

Calcium lead silicate – $2CaO\cdot PbO\cdot 3SiO_2$ – 515.55 – D 3.99 (469) – R.I. p –, m 1.795, g – (469)

Calcium lead silicate, hydrate – $4CaO\cdot 6PbO\cdot 6SiO_2\cdot H_2O$ (Nat. Ganomalite) – 1941.96 – Tetragonal – D 5.74 (469) – R.I. o 1.910, e 1.945 (469)

Calcium magnesium aluminum silicate – $CaO\cdot MgO\cdot Al_2O_3\cdot SiO_2$ (Nat. Gehlenite) – 258.40 – Tetragonal – D 3.04 (469) – R.I. o 1.666, e 1.661 (469)

Calcium magnesium carbonate – $CaMg(CO_3)_2$ (Nat. Dolomite) – 184.42 – Colorless – Trigonal – D 2.872 (469) – D.T. 725 (337) – R.I. o 1.6817, e 1.5026 (469)

Calcium magnesium fluoride – $CaF_2\cdot 2MgF_2$ (Nat. Zamboninite) – 202.72 – Rhombic – R.I. p 1.405, m –, g 1.411 (959)

Calcium magnesium iron (III) aluminate – $4CaO\cdot 2MgO\cdot Fe_2O_3\cdot Al_2O_3$ – 566.58 – Brown – D 3.72 (393) – M.P. 1370 (Incong.) – T.P. 1300 (393) – R.I. p 1.92, m –, g 1.97 (All for Li line) (393)

Calcium magnesium iron (III) oxide – $2CaO\cdot MgO\cdot Fe_2O_3$ – 312.16 – Brown – M.P. 1410 (Incong.) (393) – R.I. p 2.13, m –, g 2.28 (All for Li line) (393)

Calcium magnesium silicate – $CaO\cdot MgO\cdot SiO_2$ (Monticellite) – 156.46 – Colorless – Rhombic – D 3.2 (469) – M.P. 149_8 (Incong.) (469) – R.I. p 1.639, m 1.646, g 1.653 (275)

Calcium magnesium silicate – $CaO\cdot MgO\cdot 2SiO_2$ (Diopside) – 216.52 – Colorless – Monoclinic – D 3.275 (8) – M.P. 1392 (893) – R.I. p 1.665, m 1.672, g 1.695 (893)

Calcium magnesium silicate – $CaO\cdot 3MgO\cdot 4SiO_2$ (Nat. Tremolite) – 417.28 – Monoclinic – D 3.0 (469) – R.I. p 1.609, m 1.623, g 1.635 (469)

Calcium magnesium silicate – $2CaO\cdot MgO\cdot 2SiO_2$ (Akermanite) – 272.60 – Tetragonal – D 2.944 (469) – M.P. 1458 (469) – R.I. o 1.633, e 1.639 (469)

Calcium magnesium silicate – $2CaO \cdot MgO \cdot 2SiO_2$ (Glass) – 272.60 – Colorless – D 2.955 (273) – R.I. 1.641 (273)

Calcium magnesium silicate – $3CaO \cdot MgO \cdot 2SiO_2$ (Nat. Merwinite) – 328.68 – Colorless – Monoclinic – D 3.15 (469) – R.I. p 1.708, m 1.711, g 1.718 (469)

Calcium magnesium silicate – $5CaO \cdot 2MgO \cdot 6SiO_2$ – 721.40 – Rhombic – M.P. 1365 (Incong.) (469) – R.I. p 1.621, m 1.627, g 1.635 (469)

Calcium manganese carbonate – $CaMn(CO_3)_2$ (Nat. Mangandolomite) – 215.03 – Trigonal – R.I. o 1.741, e 1.536 (295)

Calcium manganese silicate – $CaO \cdot MnO \cdot SiO_2$ (Glaucochroite) – 187.07 – Pale pink – Rhombic – D 3.39 (1007) – M.P. 1230 (in N_2) (1007) – R.I. p 1.679, m 1.716, g 1.729 (617)

Calcium manganese silicate – $CaO \cdot MnO \cdot 2SiO_2$ (Nat. Schaller) – 247.13 Monoclinic – D 3.6 (897) – R.I. p 1.710, m 1.719, g 1.738 (897)

Calcium manganese silicate – $CaO \cdot MnO \cdot 2SiO_2$ (Nat. Bustamite) – 247.13 – Pale pink – Triclinic – D 3.32 (617) – R.I. p 1.672, m 1.685, g 1.687 (617)

Calcium molybdate – $CaO \cdot MoO_3$ – 200.03 – Colorless – Tetragonal – D 4.35 (469) – R.I. o 1.967, e 1.978 (469)

Calcium neodymium silicate – $CaO \cdot Nd_2O_3 \cdot 2SiO_2$ – 512.74 – Colorless – Hexagonal – R.I. o 1.903, e 1.898 (256)

Calcium nitrate – $Ca(NO_3)_2$ – 164.10 – Colorless – Cubic – D 2.36 (469) – M.P. 561 (469) – R.I. 1.595 (1075)

Calcium nitrate, hydrate – $Ca(NO_3)_2 \cdot 3H_2O$ – 218.14 – M.P. 51.1 (469)

Calcium nitrate, hydrate – $Ca(NO_3)_2 \cdot 4H_2O$(I) – 236.16 – Colorless – Monoclinic – D 1.82 (469) – M.P. 42.7 (469) – R.I. p 1.465, m 1.498, g 1.504 (469)

Calcium nitrate, hydrate – $Ca(NO_3)_2 \cdot 4H_2O$(II) – 236.16 – Colorless – M.P. 39.7 (469)

Calcium nitrite – $Ca(NO_2)_2$ – 132.09 – D 2.265 (157) – T.P. 138 (157) – D.T. 250 (157)

Calcium oxalate – CaC_2O_4 – 128.10 – Colorless – Cubic – D 2.2^4 (469)

Calcium oxide – CaO – 56.08 – Colorless – Cubic – D 3.32^{25} (218) – M.P. 2572 (469) – T.P. 420 (469) – B.P. 2850 (469) – R.I. 1.837 (1075)

Calcium oxide, per-, hydrate – $CaO_2 \cdot 8H_2O$ – 216.21 – Colorless – Tetragonal – D 1.70 (741)

Calcium phosphate, meta- – $CaO \cdot P_2O_5$ – 198.12 – Colorless – D 2.82 (469) – M.P. 975 (469) – T.P. 550 (119) – R.I. p 1.588, m –, g 1.595 (1017)

Calcium phosphate, pyro- – $2CaO \cdot P_2O_5$(I) – 254.20 – M.P. 1300 (1017) – R.I. p 1.585, m –, g 1.604 (1017)

Calcium phosphate, pyro- – $2CaO \cdot P_2O_5$(II) – 254.20 – Colorless – D 3.09 (469) – Transition to I 1150 (1017) – R.I. p 1.624, m –, g 1.628 (1017)

Calcium phosphate, ortho- – $3CaO \cdot P_2O_5$ (Nat. Whitlockite) – 310.28 – Colorless – Rhombohedral – D 3.12 (313) – R.I. o 1.629, e 1.626 (313)

Calcium phosphate, ortho- – $3CaO \cdot P_2O_5$(I) – 310.28 – Colorless – M.P. 1730 (1017) – R.I. p 1.588, m –, g 1.591 (1017)

Calcium phosphate, ortho- – $3CaO \cdot P_2O_5$(II) – 310.28 – Colorless – D 3.068^{15} (457) – Transition to I about 1400 (1017) – R.I. p 1.620, m –, g 1.622 (1017)

Calcium phosphate – $4CaO \cdot P_2O_5$ – 366.36 – Colorless – Monoclinic – D 3.06 (469) – M.P. 1700 (1017) – R.I. p 1.643, m –, g 1.647 (1017)

Calcium phosphate – $10CaO \cdot 3P_2O_5$ (Nat. Oxydapatite) – 986.92 – Colorless – Hexagonal – D 2.89 (469) – M.P. 1540 (469) – R.I. o 1.633, e 1.629 (617)

Calcium phosphate, hydrate – $CaO \cdot P_2O_5 \cdot 2H_2O$ – 234.15 – Colorless – Triclinic – D 2.546^{16} (469)

Calcium phosphate, hydrate – $CaO \cdot P_2O_5 \cdot 3H_2O$ – 252.17 – Colorless – Triclinic – D 2.220^{16} (469) – —$2H_2O$ 109, —$3H_2O$ 325 (622) – R.I. p 1.5292, m 1.5176, g 1.4932 (622)

Calcium phosphate, hydrate – $2CaO \cdot P_2O_5 \cdot H_2O$ (Monetite) – 272.22 – Colorless – Triclinic – D 2.928 (320) – R.I. p 1.604, m –, g 1.623 (320)

Calcium phosphate, hydrate – $2CaO \cdot P_2O_5 \cdot 5H_2O$ (Brushite) – 344.28 – Colorless – Triclinic – D 2.326 (990) – —$2H_2O$ 150, —$4H_2O$ 185 (622) – R.I. p 1.5576, m 1.5457, g 1.5392 (622)

Calcium phosphate chloride – $Ca_3(PO_4)_2 \cdot CaCl_2$ (Spodiosite) – 421.27 – Colorless – Rhombic – D 3.041^{28} (166) – R.I. p 1.649, m 1.665, g 1.670 (166)

Calcium phosphate chloride – $3Ca_3(PO_4)_2 \cdot CaCl_2$ (Chloroapatite) – 1041.83 – Colorless – Hexagonal – D 3.010 (166) – M.P. 1570 (1016) – R.I. o 1.667, e 1.666 (469)

Calcium phosphate chloride fluoride – $3Ca_3(PO_4)_2 \cdot CaClF$ – 1025.37 – Colorless – D 3.14 (469) – M.P. 1270 (469) – R.I. o 1.634, e 1.631 (469)

Calcium phosphate fluoride – $3Ca_3(PO_4)_2 \cdot CaF_2$ (Fluorapatite) – 1008.92 – Colorless – Hexagonal – D 3.2 (617) – M.P. 1660 (1016) – R.I. o 1.633, e 1.630 (617)

Calcium phosphate fluoride – $3Ca_3(PO_4)_2 \cdot CaF_2$ (Fluorapatite) – 1008.92 – Colorless – Hexagonal – D 3.18^{25} (469) – M.P. 1630 (469) – R.I. o 1.6325, e 1.629 (469)

Calcium phosphate hydroxide – $3Ca_3(PO_4)_2 \cdot Ca(OH)_2$ (Hydroxyapatite) – 1004.94 – Colorless – Hexagonal – D 3.076 (158 a) – D.T. 1400 (1016) – R.I. o 1.6452, e 1.6413 (158 a)

Calcium selenate – $CaO \cdot SeO_3$ – 183.04 – Colorless – D 2.88 (417)

Calcium selenate, hydrate – $CaO \cdot SeO_3 \cdot 2H_2O$ – 219.07 – Colorless – Monoclinic – D 2.68 (469)

Calcium selenide – CaSe – 119.04 – Colorless – Cubic – D 3.57 (417) – R.I. 2.274 (384)

Calcium silicate – $CaO \cdot SiO_2(I)$ (Pseudo-Wollastonite) – 116.14 – Colorless – Monoclinic – D 2.904^{25} (218) – M.P. 1540 (469) – R.I. p 1.610, m 1.611, g 1.654 (469)

Calcium silicate – $CaO \cdot SiO_2(II)$ (Wollastonite) – 116.14 – Colorless – Triclinic – D 2.906^{21} (218) – T.P. 1200 (469) – R.I. p 1.616, m 1.629, g 1.631 (469)

Calcium silicate – $CaO \cdot SiO_2$ (Nat. Parawollastonite) – 116.14 – Colorless – Monoclinic – R.I. p 1.620, m 1.631, g 1.633 (776)

Calcium silicate – $CaO \cdot SiO_2$ (Glass) – 116.14 – Colorless – D 2.904 (703) – R.I. 1.6280 (615)

Calcium silicate – $CaO \cdot 2SiO_2$ (Nat. Apophyllite) – 176.20 – Colorless – Hexagonal – R.I. o 1.534, e 1.537 (610)

Calcium silicate – $2CaO \cdot SiO_2(I)$ – 172.22 – Colorless – Monoclinic – D 3.27 (219) – M.P. 2130 (469) – R.I. p 1.717, m –, g 1.735 (708)

Calcium silicate – $2CaO \cdot SiO_2(II)$ – 172.22 – Rhombic – D 3.28 (219) – Transition to I 1420 (469) – R.I. p 1.717, m –, g 1.735 (469)

Calcium silicate – $2CaO \cdot SiO_2(II')$ – 172.22 – Colorless – Monoclinic – R.I. p –, m 1.715, g – (822)

Calcium silicate – $2CaO \cdot SiO_2(III)$ – 172.22 – Colorless – Monoclinic – D 2.97 (219) – Transition to II 675 (469) – R.I. p 1.642, m 1.645, g 1.654 (469)

Calcium silicate – $3CaO \cdot SiO_2$ – 228.30 – Colorless – Monoclinic – M.P. 1900 (Incong.) (469) – R.I. p 1.718, m –, g 1.724 (629)

Calcium silicate – $3CaO \cdot 2SiO_2$ (Akermannite) – 288.36 – Colorless – Rhombic – M.P. 1475 (Incong.) (469) – R.I. p 1.641, m 1.645, g 1.650 (274)

Calcium silicate, hydrate – $CaO \cdot SiO_2 \cdot H_2O$ – 134.16 – Colorless – R.I. p –, m 1.603, g – (285)

Calcium silicate, hydrate – $CaO \cdot 2SiO_2 \cdot 2H_2O$ (Nat. Okenite) – 212.23 – Rhombic – D 2.3 (469) – R.I. o 1.530, e 1.541 (285)

Calcium silicate, hydrate – $2CaO \cdot SiO_2 \cdot H_2O$ – 190.24 – Needle – R.I. p –, m 1.598, g – (516)

Calcium silicate, hydrate – $2CaO \cdot SiO_2 \cdot H_2O$ – 190.24 – Colorless – Lath-like prism – D 2.8 (1033) – R.I. p 1.614, m 1.620, g 1.633 (1033)

Calcium silicate, hydrate – $2CaO \cdot SiO_2 \cdot H_2O$ (Nat. Hillebrandite) – 190.24 – Colorless – Rhombic – D 2.69 (469) – R.I. p 1.605, m 1.61, g 1.612 (469)

Calcium silicate, hydrate – $2CaO \cdot 2SiO_2 \cdot 3H_2O$ (Nat. Crestmoreite) – 286.34 – Colorless – Monoclinic – R.I. p 1.593, m 1.603, g 1.607 (285)

Calcium silicate, hydrate – $2CaO \cdot 2SiO_2 \cdot 3H_2O$ (Nat. Riversideite) – 286.34 – Colorless – D 2.64 (617) – R.I. p 1.595, m 1.60, g 1.603 (469)

Calcium silicate, hydrate – $2CaO \cdot 3SiO_2 \cdot 2H_2O$ (Nat. Centrallasite) – 328.38 – Colorless – Monoclinic – R.I. p 1.535, m 1.548, g 1.549 (45)

Calcium silicate, hydrate – $2CaO \cdot 3SiO_2 \cdot 2H_2O$ (Nat. Gyrolite) – 328.38 – Colorless – Trigonal – R.I. o 1.548, e 1.536 (285)

Calcium silicate, hydrate – $3CaO \cdot SiO_2 \cdot 2H_2O$ – 264.33 – R.I. p 1.590, m –, g 1.602 (285)

Calcium silicate, hydrate – $3CaO \cdot 2SiO_2 \cdot 3H_2O$ (Nat. Afwillite) – 342.41 – Colorless – Monoclinic – D 2.63 (617) – R.I. p 1.617, m 1.620, g 1.634 (285)

Calcium silicate, hydrate – $4CaO \cdot 4SiO_2 \cdot 7H_2O$ (Nat. Crestmoreite) – 590.69 – Colorless – Rhombic – D 2.22 (469) – R.I. p 1.593, m 1.603, g 1.607 (469)

Calcium silicate, hydrate – $4CaO \cdot 5SiO_2 \cdot 5H_2O$ (Tobermorite) – 614.72 – Acicular – R.I. p –, m 1.54, g – (285)

Calcium silicate, hydrate – $4CaO \cdot 7SiO_2 \cdot 3H_2O$ (Nat. Centrallasite) – 698.79 – Colorless – Plate – D 2.51 (617) – R.I. p 1.535, m 1.548, g 1.549 (617)

Calcium silicate, hydrate – $5CaO \cdot 3SiO_2 \cdot 3H_2O$ (Nat. Foshagite) – 514.64 – Colorless – Rhombic – R.I. p 1.594, m 1.594, g 1.598 (285)

Calcium silicate, hydrate – $5CaO \cdot 5SiO_2 \cdot H_2O$ (Xonotlite) – 598.72 – Colorless – Rhombic – R.I. p 1.583, m 1.583, g 1.594 (285)

Calcium silicate, hydrate – $6CaO \cdot 3SiO_2 \cdot 2H_2O$ – 552.69 – Colorless – R.I. p 1.642, m –, g 1.672 (285)

Calcium silicate, hydrate – $6CaO \cdot 4SiO_2 \cdot 3H_2O$ – 630.77 – Fibrous – R.I. p –, m 1.60, g – (285)

Calcium silicate, hydrate – $10CaO \cdot 5SiO_2 \cdot 6H_2O$ – 969.20 – Rhombic – R.I. p 1.614, m 1.620, g 1.633 (285)

Calcium silicate, boro- – $CaO \cdot B_2O_3 \cdot 2SiO_2$ (Nat. Danburite) – 245.84 – Colorless – Rhombic – D 3.0 (469) – R.I. p 1.630, m 1.633, g 1.636 (617)

Calcium silicate, boro- – $5CaO \cdot B_2O_3 \cdot SiO_2$ – 410.10 – Colorless – M.P. 1419 (287) – R.I. p 1.666, m –, g 1.690 (287)

Calcium silicate, boro-, hydrate – $2CaO \cdot B_2O_3 \cdot 2SiO_2 \cdot H_2O$ (Nat. Datolite) – 319.94 – Colorless – Monoclinic – D 3.0 (469) – R.I. p 1.625, m 1.653, g 1.669 (469)

Calcium silicate, boro-, hydrate – $4CaO \cdot 5B_2O_3 \cdot 2SiO_2 \cdot 5H_2O$ (Nat. Howlite) – 782.72 – Colorless – Monoclinic – D 2.6 (469) – R.I. p 1.586, m 1.598, g 1.605 (469)

Calcium silicate, boro-, hydrate – $8CaO \cdot 5B_2O_3 \cdot 6SiO_2 \cdot 6H_2O$ (Nat. Bakerite) – 1265.30 – Colorless – D 2.8 (469) – R.I. p –, m 1.583, g – (469)

Calcium silicate carbonate – $3CaO \cdot SiO_2 \cdot CO_2$ (Nat. Tilleyite) – 272.31 – Colorless – Monoclinic – D 2.823 (617) – R.I. p 1.617, m 1.635, g 1.652 (617)

Calcium silicate carbonate – $4CaO \cdot 2SiO_2 \cdot CO_2$ (Spurrite) – 388.45 – Colorless – Rhombic and Triclinic – D 3.01 (469) – T.P. 1200 (252) – D.T. 1380 (122 atm.) (252) – R.I. p 1.640, m 1.674, g 1.679 (469)

Calcium silicate carbonate – $4CaO \cdot 3SiO_2 \cdot 2CO_2$ (Nat. Scawtite) – 492.52 – Colorless – Monoclinic – D 2.77 (617) – R.I. p 1.597, m 1.606, g 1.621 (617)

Calcium silicate, fluo- – $CaF_2 \cdot SiF_4$ – 182.14 – Colorless – Tetragonal – D 2.66^{18} (609)

Calcium silicate fluoride – $3CaO \cdot 2SiO_2 \cdot CaF_2$ (Nat. Cuspidine) – 366.44 – Colorless – Monoclinic – D 2.92 (617) – R.I. p 1.590, m 1.595, g 1.602 (617)

Calcium silicate phosphate – $5CaO \cdot SiO_2 \cdot P_2O_5$ – 482.50 – Colorless – D 3.01 (469) – M.P. 1760 (469)

Calcium silicate phosphate – $7CaO \cdot 2SiO_2 \cdot P_2O_5$ – 654.72 – Colorless – D 3.035 (720) – R.I. p 1.652, m –, g 1.661 (720)

Calcium sulfate – $CaSO_4$(I) – 136.14 – Colorless – Monoclinic – M.P. 1300 (521) – R.I. p 1.50, m –, g 1.56 (1075)

Calcium sulfate – $CaSO_4$(II) (Anhydrite) – 136.14 – Colorless – Rhombic or Monoclinic – D 2.960 (1089) – Transition to I 1193 (799) – R.I. p 1.5693, m 1.5752, g 1.6130 (469)

Calcium sulfate – $CaSO_4$(III) ("Soluble Anhydrite") – 136.14 – Colorless – Hexagonal or Triclinic – D 2.61 (321) – Transition to II $>$ 200 (799) – R.I. o 1.505, e 1.548 (321)

Calcium sulfate, hydrate – $CaSO_4 \cdot 1/2H_2O$ – 145.15 – Colorless – Monoclinic – D 2.58 (644) – R.I. p 1.559, m 1.5595, g 1.5836 (315)

Calcium sulfate, hydrate – $CaSO_4 \cdot 2H_2O$ (Gypsum) – 172.17 – Colorless – Monoclinic – D 2.3114 (1089) – Transition to $CaSO_4 \cdot 1/2H_2O$ at 97.5, transition to $CaSO_4$(II) at 42 (799) – R.I. p 1.5205, m 1.5224, g 1.5296 (469)

Calcium sulfate, hydrate – $CaSO_4 \cdot 2D_2O$ – 176.19 – $-2D_2O$ at 107 (150)

Calcium sulfide – CaS – 72.14 – Colorless – Cubic – D 2.56^{24} (18) – R.I. 2.137 (384)

Calcium telluride – CaTe – 167.69 – Cubic – D 4.873 (386) (955) – R.I. $>$ 2.51 (384)

Calcium tin (IV) borate – $CaO \cdot SnO_2 \cdot B_2O_3$ (Nat. Nordenskiöldine) – 276.42 – Colorless – Hexagonal – D 4.2 (469) – R.I. o 1.778, e 1.660 (820)

Calcium titanate – $CaO \cdot TiO_2$ – 135.98 – Colorless – Cubic, Rhombic – D 4.10 (469) – M.P. 1975 (1053) – R.I. 2.34 (619)

Calcium titanate – $2CaO \cdot TiO_2$ – 192.06 – M.P. 1800 (1053)

Calcium titanate – $3CaO \cdot TiO_2$ – 248.14 – M.P. 2135 (1053)

Calcium titanium antimonate – $5CaO \cdot 2TiO_2 \cdot 2Sb_2O_5$ (Nat. Lewisite) – 1087.24 – Honey yellow – Cubic – D 4.95 (469) – R.I. 2.20 (469)

Calcium titanium silicate – $CaO \cdot TiO_2 \cdot SiO_2$ (Titanite) – 196.04 – Colorless – Monoclinic – D 3.5 (469) – M.P. 1382 (476) – R.I. p 1.900, m 1.907, g 2.034 (469)

Calcium titanium sulfate – $CaTi(SO_4)_3$ – 376.16 – Colorless – Cubic – R.I. 1.4736 (476)

Calcium tungstate – $CaO \cdot WO_3$ (Scheelite) – 288.00 – Colorless – Tetragonal – D 6.062^{20} (1108) – R.I. o 1.9200, e 1.9365 (1113)

Calcium vanadate – $CaO \cdot V_2O_5$ – 237.98 – M.P. 778 (710)

Calcium vanadate – $CaO \cdot 2V_2O_5$ – 419.88 – M.P. 637 (469)

Calcium vanadate – $2CaO \cdot V_2O_5$ – 294.06 – M.P. 1015 (710)

Calcium vanadate – $3CaO \cdot V_2O_5$ – 350.14 – M.P. 1380 (710)

Calcium vanadate, hydrate – $CaO \cdot V_2O_5 \cdot 2H_2O$ (Nat. Metarossite) – 274.03 – Yellow – R.I. p 1.840, m $>$ 1.850, g $>$ 1.850 (298)

Calcium vanadate, hydrate – $CaO \cdot V_2O_5 \cdot 4H_2O$ (Nat. Rossite) – 310.06 – Yellow – Triclinic – D 2.45 (1075) – R.I. p 1.710, m 1.770, g 1.840 (298)

Calcium vanadate, hydrate – $CaO \cdot 3V_2O_5 \cdot 9H_2O$ (Nat. Hewettite) – 763.92 – Rhombic – D 2.554 (469) – R.I. p 1.77, m 2.18, g 2.35 (469)

Calcium vanadate, hydrate – $CaO \cdot 3V_2O_5 \cdot 9H_2O$ (Nat. Metahewettite) – 763.92 – Rhombic – D 2.51 (469) – R.I. p 1.70, m 2.10, g 2.23 (469)

Calcium vanadate, hydrate – $2CaO \cdot 3V_2O_5 \cdot 11H$ O (Nat. Pascoite) – 856.0 – Monoclinic – D 2.46 (469) – R.I. p 1.775, m 1.815, g 1.825 (469)

Calcium yttrium fluoride – $5CaF_2 \cdot 2YF_3$ – 682.24 – Colorless – Hexagonal – D 3.19 (1076) – R.I. o 1.45, e – (1076)

Calcium zinc arsenate – $3CaO \cdot 4ZnO \cdot 2As_2O_5$ (Nat. Brickerite) – 953.40 – Colorless – Triclinic – D 4.13^{22} (4) – R.I. p 1.752, m 1.755, g 1.779 (4)

Calcium zinc arsenate, hydrate – $2CaO \cdot 2ZnO \cdot As_2O_5 \cdot H_2O$ (Nat. Austinite) – 522.76 – Colorless – Rhombic – D 4.12 (958) – R.I. p 1.759, m 1.763, g 1.783 (958)

Calcium zinc silicate – $2CaO \cdot ZnO \cdot SiO_2$ (Nat. Hardystonite) – 253.60 – Colorless – Tetragonal – D 3.4 (469) – R.I. o 1.669, e 1.657 (469)

Calcium zinc silicate – $2CaO \cdot ZnO \cdot 2SiO_2$ (Nat. Hardystonite) – 313.66 – Colorless – Tetragonal – R.I. o 1.6722, e 1.6609 (452)

Calcium zinc silicate, hydrate – $CaO \cdot ZnO \cdot SiO_2 \cdot H_2O$ (Nat. Klinoedrite) – 215.54 – Colorless – Monoclinic – D 3.33 (469) – R.I. p –, m 1.670, g – (469)

Calcium zirconate – $CaO \cdot ZrO_2$ – 179.30 – Colorless – Monoclinic – D 4.78 (877) – M.P. 2345 (611)

Carbon – C – 12.010 – Black – M.P. 3700 (14) (1026) – S.P. 4827 (15)

Carbon – C (Nat. Diamond) – 12.010 – Colorless – D 3.513^{25} (858) – R.I. 2.4173 (469)

Carbon – C (Graphite) – 12.010 – Black – Hexagonal – D 2.26^{20} (858)

Carbon – C (Transparent Graphite) – 12.010 – Transparent – Hexagonal flakes – D 2.15 (794) – R.I. 2.0 (794)

Carbon chloride, tetra- – CCl_4 – 153.838 – Colorless liquid – D 1.58413^{25} (372) 1.925^{-79} (Solid) (92) – M.P. —22.870 – T.P. — 47.66 (500) – B.P. 76.71 (372) – R.I. 1.46044^{20} (1128)

Carbon fluoride, tetra- – CF_4 – 88.01 – Colorless gas – D 1.98^{-195} (549) – M.P. — 186.8 (549) – T.P. — 196.94 (14) – B.P. — 127.9 (519)

Carbon oxide, mono- – CO – 28.010 – Colorless gas – D 0.8138^{-195} (469) – M.P. — 205.01 – T.P. — 211.6 (191) – B.P. — 191.47 (14)

Carbon oxide, di- – CO_2 – 44.010 – Colorless gas – D 1.53^{-79} (469) – M.P. —57.5 (521) – S.P. — 78.5 (519)

Carbon selenide, di- – CSe_2 – 169.93 – Golden yellow liquid – D 2.679 (373) – M.P. — 45.5 (373) – B.P. 124 (373) – R.I. 1.8454 (373)

Carbon sulfide, di- – CS_2 – 76.13 – Colorless liquid – D 1.2622^{20} (469) – M.P. 110.8 (521) – B.P. 46.3 (519) – R.I. 1.6276 (20°C.) (675)

Cerium – Ce – 140.13 – Iron gray – Cubic – D 6.9^{20} (15) – M.P. 600 (14) (1026) – B.P. 1400 (15)

Cerium (III) carbonate fluoride – $CeFCO_3$ (Nat. Bastnaesite) – 219.14 – Hexagonal – D 5.0 (469) – R.I. o 1.717, e 1.817 (469)

Cerium (III) chloride – $CeCl_3$ – 246.50 – Colorless – D 3.97 (540) – M.P. 822 (540)

Cerium chromite – $Ce_2O_3 \cdot Cr_2O_3$ (or $2CeO_2 \cdot Cr_2O_3$) – 480.28 – M.P. 2430 (1049)

Cerium (III) fluoride – CeF_3 (Fluocerite) – 197.13 – Colorless – Hexagonal – D 5.8 (469) – M.P. 1460 (1048) – R.I. o 1.613, e 1.607 (469)

Cerium (IV) fluoride – CeF_4 – 216.13 – Colorless – D 3.1-4.77 (550)

Cerium (III) molybdate – $Ce_2O_3 \cdot 3MoO_3$ – 1047.96 – Yellow – Tetragonal – D 4.83 (469) – M.P. 973 (469) – R.I. o 2.019, e 2.007 (6670 Å) (469)

Cerium (III) oxide – Ce_2O_3 – 328.26 – Grayish green – Trigonal – D 6.86 (X-ray) (1101) – M.P. 1692 (469)

Cerium (IV) oxide – CeO_2 – 172.13 – Brownish white – Cubic – D 7.132^{23} (869) – M.P. $>$ 2600 (1050)

Cerium (III) phosphate – $Ce_2O_3 \cdot P_2O_5$ (Nat. Monazite) – 470.30 – Red and yellow – Monoclinic, Rhombic – D 5.22 (469) – R.I. p 1.795, m –, g – (611)

Cerium (III) phosphate – $Ce_2O_3 \cdot 3P_2O_5$ – 754.38 – Needle – D 3.27 (469)

Cerium (IV) phosphate, hydrate – $3CeO_2 \cdot 2P_2O_5 \cdot 11H_2O$ – 1467.04 – Pale green – — $6H_2O$ at 200, — $11H_2O$ at 500 (30)

Cerium (III) selenide – Ce_2Se_3 – 517.14 – Bluish black – D 6.34 (551)

Cerium (IV) selenide – Ce_2Se_4 – 596.10 – D 6.53 (551)

Cerium (IV) sulfate – $Ce(SO_4)_2$ – 332.25 – Deep yellow – D 3.91^{18} (53) – D.T. 195 (765)

Cerium (III) sulfate – $Ce_2(SO_4)_3$ – 568.44 – Colorless to green – Monoclinic or Rhombic – D 3.912 (469) – D.T. 920 (746 mm.) (765)

Cerium (III) sulfate, hydrate – $Ce_2(SO_4)_3 \cdot 5H_2O$ – 658.52 – Monoclinic – D 3.17 (469)

Cerium (III) sulfate, hydrate – $Ce_2(SO_4)_3 \cdot 8H_2O$ – 712.57 – Smoke pink – Triclinic – D 2.886^{17} (469) – $-8H_2O$ at 630 (469)
Cerium (III) sulfate, hydrate – $Ce_2(SO_4)_3 \cdot 9H_2O$ – 730.59 – Hexagonal – D 2.831 (469)
Cerium (III) sulfide – Ce_2S_3 – 376.44 – Yellow – D 5.10^{25} (552) – M.P. 2100 (in vacuum) (793)
Cerium (IV) sulfide – Ce_2S_4 – 408.50 – D 4.90^{25} (552)
Cerium (III) tungstate – $Ce_2O_3 \cdot 3WO_3$ – 1024.02 – Pale yellow – Tetragonal – D 6.77^{17} (469) – M.P. 1089 (469)
Cesium – Cs – 132.91 – D 1.9^{20} (15) – M.P. 28 (14) (1026) – B.P. 670 (15)
Cesium aluminum fluoride – $3CsF \cdot AlF_3$ – 539.70 – M.P. 823 (469)
Cesium beryllium fluoride – $2CsF \cdot BeF_2$ – 350.84 – Colorless – D 4.213^{30} (826)
Cesium borate, fluo- – $CsF \cdot BF_3$ – 219.73 – Rhombic – D 3.305 (1115) – M.P. 550 (105) – R.I. p –, m 1.36, g – (1115)
Cesium carbonate – Cs_2CO_3 – 325.83 – Colorless – Needle – D.T. 1447 (760 mm.) (520)
Cesium chloride – CsCl (I) – 168.37 – Colorless – Cubic – M.P. 642 (521) – B.P. 1300 (519)
Cesium chloride – CsCl(II) – 168.37 – Colorless – Cubic – D 3.983 (1086) – Transition to I 445 (1039) – R.I. 1.63966^{25} (1086)
Cesium chromate – $Cs_2O \cdot CrO_3$ – 381.83 – Yellow – Rhombic, Trigonal – D 4.35 (X-ray) (693)
Cesium chromate, di- – $Cs_2O \cdot 2CrO_3$ – 481.84 – R.I. o > 1.95, e > 1.95 (976)
Cesium fluoride – CsF – 151.91 – D 4.115 (416)
Cesium fluoride – CsF(I) – 151.91 – Colorless – Cubic – D 5.34 (828) – 684 (1054) – B.P. 1251 (519) – R.I. 1.578 (954)
Cesium fluoride – CsF(II) – 151.91 – Colorless – Cubic – D 4.52 (X-ray) (807) – R.I. 1.478 (807)
Cesium formate – $CsHCO_2$ – 177.93 – Colorless – Prisms – M.P. 265 (931)
Cesium germanium fluoride – $2CsF \cdot GeF_4$ – 452.42 – Colorless – Cubic – D 4.107 (X-ray) (904) – R.I. 1.430 (904)
Cesium hydroxide – CsOH – 149.92 – Colorless – Cubic – D 3.675^{11} (469) – M.P. 272.3 – T.P. 223 (469)
Cesium manganate, per- – $CsMnO_4$ – 251.84 – Dark violet – Rhombic – D 3.60 (469) – D.T. 320 (208)
Cesium nitrate – $CsNO_3$(I) – 194.92 – Colorless – Cubic – D 3.685 (469) – M.P. 407 (521) – B.P. 740 (648)
Cesium nitrate – $CsNO_3$(II) – 194.92 – Colorless – Hexagonal – Transition to I 161 (469) – R.I. o 1.55, e 1.56 (1075)
Cesium nitrate, acid- – $CsNO_3 \cdot HNO_3$ – 257.93 – Colorless – Cubic – M.P. 100 (469)
Cesium nitrate, acid- – $CsNO_3 \cdot 2HNO_3$ – 320.95 – Colorless – Plates – M.P. 35 (469)
Cesium oxide – Cs_2O – 281.82 – Pale yellow – Hexagonal – D 4.36 (469) – M.P. 490 (in N_2) (833)
Cesium oxide, per- – Cs_2O_2 – 297.82 – Pale yellow – Needle – D 4.47 (832) – M.P. 594 (175) – D.T. 1074 (760 mm.) (175)
Cesium phosphate, fluo- – $CsF \cdot PF_5$ – 277.89 – D 3.32^{19} (614)
Cesium selenate – $Cs_2O \cdot SeO_3$ – 408.78 – Rhombic – D 4.456 (1021) – R.I. p 1.599, m 1.600, g 1.600 (469)
Cesium selenide – Cs_2Se – 344.78 – Colorless – D.T. 660 (61)
Cesium silicate, fluo- – $2CsF \cdot SiF_4$ – 407.88 – Colorless – Cubic – D 3.372^{17} (469) – R.I. 1.391 (904)
Cesium sulfate – Cs_2SO_4 – 361.88 – Colorless – Rhombic, Hexagonal – D 4.243 (469) – M.P. 1010 (469) – T.P. 660 (469) – R.I. p 1.560, m 1.564, g 1.566 (469)
Cesium sulfate, acid- – $CsHSO_4$ – 229.98 – Colorless – Rhombic – D 3.352^{16} (469) – R.I. o 1.505, e 1.50 (976)
Cesium sulfide, per- – Cs_2S_2 – 329.94 – Dark red – M.P. 460 (469)
Cesium titanium fluoride – $2CsF \cdot TiF_4$ – 427.72 – M.P. 690 (339)
Chloric acid, per- – $HClO_4$ – 100.465 – Colorless liquid – D 1.768^{20} (1095) – M.P. — 112 (1095) – B.P. 130 (Extrapolated) (396)
Chlorine – Cl (Cl_2) – 35.457 – Yellowish green gas – M.P. — 101 (14) (1026) – B.P. — 34.05 (333)
Chlorine oxide, di- – ClO_2 – 67.457 – Yellowish liquid – D 1.642^{0} (176) – M.P. — 59 (537) – B.P. 11.0 (537)
Chlorine oxide, tri- – Cl_2O_6 – 166.914 – Deep red liquid – D 1.65 (469) – M.P. — 1 (469)
Chlorine oxide, hept- – Cl_2O_7 – 182.914 – Colorless liquid – M.P. — 91.5 (356) – B.P. 80 (356)

Chromium – Cr – 52.01 – Grayish white – Cubic – D7.103$^{22.3}$ (430) – M.P. 1800 (14) (1026) – B.P. 2482 (15)
Chromium (II) chloride – $CrCl_2$ – 122.92 – D 2.878^{25} (75) – M.P. 824 (280)
Chromium (III) chloride – $CrCl_3$ – 158.38 – Violet – Trigonal – D 2.782^{25} (75) – M.P. $\sim$ 1150 (280)
Chromium (II) fluoride – CrF_2 – 90.01 – Gray – Monoclinic – D 4.11 (469) – M.P. 1100 (469) – B.P. > 1300 (469)
Chromium (III) fluoride – CrF_3 – 109.01 – Green – Rhombic – D 3.8 (469) – M.P. > 1000 (469) – S.P. 1100-1200 (675)
Chromium (III) nitrate, hydrate – $Cr(NO_3)_3 \cdot 9H_2O$ – 400.18 – Purple – Rhombic – M.P. 36.5 (675) – D.T. 100 (675)
Chromium (III) oxide – Cr_2O_3 – 152.02 – Green – Triclinic, Hexagonal – D 5.21 (469) – M.P. 2435 (1049) – R.I. Mean 2.5 (1075)
Chromium (VI) oxide – CrO_3 – 100.01 – Red – Rhombic – D 2.811^{28} (457) – M.P. 190 (469)
Chromium (III) phosphate, meta- – $Cr_2O_3 \cdot 3P_2O_5$ – 578.14 – Green – Rhombic – D 2.97 (469)
Chromium (III) phosphate – $2Cr_2O_3 \cdot 3P_2O_5$ – 730.16 – Green – Monoclinic – D 3.2 (469)
Chromium (III) phosphate, hydrate – $Cr_2O_3 \cdot P_2O_5 \cdot 4H_2O$ – 366.12 – Green – D 2.42^{33} (675)
Chromium (III) phosphate, hydrate – $Cr_2O_3 \cdot P_2O_5 \cdot 8H_2O$ – 438.19 – Green – D 2.10^{33} (675)
Chromium (III) phosphate, hydrate – $Cr_2O_3 \cdot P_2O_5 \cdot 12H_2O$ – 510.25 – Violet – Triclinic – D 2.12^{33} (469)
Chromium (II) selenide – CrSe – 130.97 – Black – Hexagonal – D 6.74 (X-ray) (508)
Chromium (III) sulfate – $Cr_2(SO_4)_3$ – 392.20 – Violet red – D 3.0 (469)
Chromium (III) sulfate, hydrate – $Cr_2(SO_4)_3 \cdot 18H_2O$ – 716.49 – Green – Cubic – D 1.7 ($17H_2O$) (469) – R.I. 1.564 (1075)
Chromium (II) sulfide – CrS – 84.07 – Black – Hexagonal – D 4.1 (469) – M.P. 1550 (788)
Chromium (II, III) sulfide – $CrS \cdot Cr_2S_3$ – 284.27 – Greenish black – D 3.54^{14} (1059)
Chromium (III) sulfide – Cr_2S_3 – 200.20 – Black – D 3.7 (469) – D.T. 1350 (675)
Cobalt – Co – 58.94 – Gray with reddish tinge – Hexagonal – D 8.9^{20} (15) – M.P. 1490 (14) (1026) – B.P. 2900 (15)
Cobalt (II) aluminate – $CoO \cdot Al_2O_3$ (Cobalt Blue) – 176.88 – Blue – Cubic – D 43.7^{18} (469) – M.P. 1960 (1052) – R.I. > 1.78 (Red-light) (683)
Cobalt (II) aluminate – $4CoO \cdot 3Al_2O_3$ – 605.58 – D 4.80 (469)
Cobalt (II) borate, fluo- – $CoF_2 \cdot 2BF_3$ – 232.58 – Pseudorhombic – R.I. p –, m 1.40, g – (227)
Cobalt (II) carbonate – $CoCO_3$ (Sphaerocobaltite) – 118.95 – Red – Trigonal – D 4.124 (71) – D.T. 341 (760 mm.) (597) – R.I. o 1.855, e 1.60 (469)
Cobalt (II) carbonate – $CoCl_2$ – 129.85 – Blue – Hexagonal – D 3.356^{25} (469) – M.P. 727 (521) – B.P. 1049 (469)
Cobalt (II) chromite – $CoO \cdot Cr_2O_3$ – 226.96 – Cubic – D 5.143 (724)
Cobalt (II) columbate – $CoO \cdot Cb_2O_5$ – 340.76 – Dark blue – D 5.56^{17} (675)
Cobalt (II) ferrite – $CoO \cdot Fe_2O_3$ – 234.62 – Black – Cubic – D 5.3 (724) (412) – M.P. 1570 (25)
Cobalt (II) fluoride – CoF_2 – 96.94 – Rose red – Monoclinic – D 4.46^{25} (100) – M.P. > 1000 (91)
Cobalt (III) fluoride – CoF_3 – 115.94 – Light brown – Hexagonal – D 3.88 (874)
Cobalt (II) nitrate – $Co(NO_3)_2$ – 182.95 – Pale rose – D 2.49 (Calc.) (183) – D.T. 103 (383)
Cobalt (II) nitrate, hydrate – $Co(NO_3)_2 \cdot 3H_2O$ – 237.00 – Rhombic – M.P. 91 (469)
Cobalt (II) nitrate, hydrate – $Co(NO_3)_2 \cdot 6H_2O$ – 291.05 – Red – Monoclinic – D 1.883^{25} (469) – (469) – M.P. 55.5 (1031) – R.I. p 1.38, m –, g 1.52 (1075)
Cobalt (II) oxalate – CoC_2O_4 – 146.96 – Reddish white – D 3.021^{25} (100)
Cobalt (II) oxide – CoO – 74.94 – Greenish brown – Cubic – D 6.455 (1044) – M.P. 1800 (1053)
Cobalt (II, III) oxide – $CoO \cdot Co_2O_3$ – 240.82 – Black – Cubic – D 6.07 (469)
Cobalt (III) oxide – Co_2O_3 – 165.88 – Gray – Hexagonal – D 5.18 (469)
Cobalt (II) oxide, hydrate – $CoO \cdot H_2O$ – 92.96 – Rose red – Rhombic – D 3.597^{15} (469)
Cobalt (III) oxide, hydrate – $Co_2O_3 \cdot 3H_2O$ – 219.93 – Brownish black – D 4.47 (726) – $-3H_2O$ at 280 (726)
Cobalt (II) phosphate, ortho- – $3CoO \cdot P_2O_5$ – 366.86 – Violet – D 2.587^{25} (100)
Cobalt (II) selenate – $CoO \cdot SeO_3$ – 201.90 – D 4.037 (348)
Cobalt (II) selenate, hydrate – $CoO \cdot SeO_3 \cdot 5H_2O$ – 291.98 – Triclinic – D 2.512 (348)
Cobalt (II) selenate, hydrate – $CoO \cdot SeO_3 \cdot 6H_2O$ – 310.00 – Monoclinic – D 2.32 (469) – R.I. p 1.47, m 1.5225, g 1.5227 (1075)
Cobalt (II) selenate, hydrate – $CoO \cdot SeO_3 \cdot 7H_2O$ – 328.01 – Monoclinic – D 2.135 (469)

Cobalt (II) selenide – CoSe – 137.90 – Yellow – Hexagonal – D 7.65 (469)

Cobalt (II) silicate, meta- – $CoO \cdot SiO_2$ – 135.00 – Dark violet – M.P. 1000 (Incong.) (866)

Cobalt (II) silicate, ortho- – $2CoO \cdot SiO_2$ – 209.94 – Violet – Rhombic – D 4.677^{25} (89) – M.P. 1345 (89)

Cobalt (II) silicate, fluo-, hydrate – $CoF_2 \cdot SiF_4 \cdot 6H_2O$ – 309.10 – Pink – Trigonal – D 2.09 (469) – R.I. o 1.382, e 1.387 (469)

Cobalt (II) sulfate – $CoSO_4$ – 155.00 – Red – Hexagonal – D 3.710^{25} (469) – D.T. 904 (760 mm.) (1080)

Cobalt (II) sulfate, hydrate – $CoSO_4 \cdot H_2O$ – 173.02 – Red – Monoclinic – D 3.075 (696) – — H_2O at 285 (223) – R.I. p 1.603, m 1.639, g 1.683 (618)

Cobalt (II) sulfate, hydrate – $CoSO_4 \cdot 4H_2O$ – 227.06 – Red – D 2.368^{25} (469) – Transition to $CoSO_4 \cdot H_2O$ at 120-220 (223)

Cobalt (II) sulfate, hydrate – $CoSO_4 \cdot 5H_2O$ – 245.08 – Triclinic – D 2.13 (996) – R.I. p 1.529, m 1.546, g 1.548 (618)

Cobalt (II) sulfate, hydrate – $CoSO_4 \cdot 6H_2O$ – 263.10 – Monoclinic – D 2.029^{25} (469) – Transition to $CoSO_4 \cdot 4H_2O$ at 95 (223) – R.I. p 1.531, m 1.549, g 1.552 (618)

Cobalt (II) sulfate, hydrate – $CoSO_4 \cdot 7H_2O$ (Bieberite) – 281.11 – Pink – Monoclinic and Rhombic – D 1.948 (469) – Transition to $CoSO_4 \cdot 6H_2O$ at 66 (223) – R.I. p 1.477, m 1.483, g 1.489 (469)

Cobalt (II) sulfide – CoS (Sycpoorite) – 91.00 – Red – Cubic – D 5.55 (458) – M.P. $>$ 1116 (348)

Cobalt (II, III) sulfide – $CoS \cdot Co_2S_3$ (Linnaeite) – 305.06 – Dark gray – Cubic – D 4.9 (469) – D.T. 480 (506)

Cobalt (III) sulfide – Co_2S_3 – 214.05 – Black – D 4.8 (348)

Cobalt (IV) sulfide – CoS_2 – 123.06 – Black – Cubic – D 4.73 (458)

Cobalt (II) telluride – CoTe – 186.55 – Brown – D 8.85 (X-ray) (508)

Cobalt (II) tin (IV) oxide – $2CoO \cdot SnO_2$ – 300.58 – Cubic – D 6.108 (723)

Cobalt (II) titanate – $2CoO \cdot TiO_2$ – 229.78 – Greenish black – Cubic – D 5.07 (453)

Cobalt (II) tungstate – $CoO \cdot WO_3$ – 306.86 – Greenish blue – Monoclinic – D 8.42 (348)

Columbium – Cb – 92.91 – White – Cubic – D 8.57^{20} (15) – M.P. 2500 (1068) – B.P $>$ 3300 (15)

Columbium chloride – $CbCl_5$ – 270.20 – Yellowish white – Acicular – D 2.75 (469) – M.P. 194 (469) – B.P. 240.5 (469)

Columbium fluoride – CbF_5 – 187.91 – Colorless – Monoclinic – D 3.29 (469) – M.P. 75.5 (469) – B.P. 225 (519)

Columbium (III) oxide – Cb_2O_3 – 233.82 – Black or bluish gray – M.P. 1777 (306)

Columbium oxide – Cb_2O_5 – 265.82 – Colorless – Rhombic – D 4.457^{25} (612) – M.P. 1520 (469)

Copper – Cu – 63.57 – Red – Cubic – D 8.94 (15) – M.P. 1083.0 (14) (1026) – B.P. 2595 (15)

Copper (II) aluminate – $CuO \cdot Al_2O_3$ – 181.51 – Chocolate color – Cubic – D 4.732^{15} (767)

Copper (I) aluminum sulfide – $4Cu_2S \cdot Al_2S_3$ – 786.92 – Metallic gray – D 5.790 (698) – M.P. 1110 (698)

Copper (II) borate – $CuO \cdot B_2O_3$ – 149.21 – Bluish green – Needle – D 3.86 (469) – M.P. 970 (381) – D.T. 875 (381)

Copper (II) borate – $CuO \cdot B_2O_3$ (Glass) – 149.21 – Blue – D 3.61 (381)

Copper (II) carbonate, oxy- – $2CuO \cdot CO_2$ (Nat. Mysorine) – 203.15 – D 4.398 (469)

Copper (II) carbonate, basic- – $CuCO_3 \cdot Cu(OH)_2$ (Nat. Malachite) – 221.17 – Dark green – Monoclinic – D 4.0 (469) – R.I. p 1.655, m 1.875, g 1.909 (469)

Copper (II) carbonate, basic- – $2CuCO_3 \cdot Cu(OH)_2$ (Nat. Azurite) – 344.75 – Blue – Monoclinic – D 3.88 (469) – D.T. 220 (469) – R.I. p 1.730, m 1.758, g 1.838 (469)

Copper (I) chloride – Cu_2Cl_2 (Nantokite) – 198.06 – Colorless – Cubic – D 4.136^{30} (1094) – M.P. 430 (521) – B.P. 1490 (519) – R.I. 1.973 (385 a)

Copper (II) chloride – $CuCl_2$ (Eriochalcite) – 134.48 – Brownish yellow – D 3.387^{25} (79) – M.P. 630 (79) – B.P. 993 (469)

Copper (II) cobalt (III) oxide – $CuO \cdot Co_2O_3$ – 245.45 – Black – Cubic – D 6.28 (X-ray) (454)

Copper (I) ferrite – $Cu_2O \cdot Fe_2O_3$ – 302.82 – Black – Hexagonal – D 5.47 (1056) – M.P. 1458 (675)

Copper (II) ferrite – $CuO \cdot Fe_2O_3$ – 239.25 – Brownish black – D 5.28 (675)

Copper (II) ferrite – $CuO \cdot Fe_2O_3$(I) – 239.25 – Steel gray – Cubic – D 5.3 (1056) – M.P. 1560 (25) – R.I. 2.71 (650)

Copper (II) ferrite – $CuO \cdot Fe_2O_3$(II) – 239.25 – Brown – Tetragonal – D 5.29 (1056) – Transition to I 350 (1056)

Copper (II) ferrite – $2CuO \cdot 3Fe_2O_3$ – 638.18 – D 5.241^{20} (432)

Copper (I) fluoride – Cu_2F_2 – 165.14 – Red – D 7.07 (X-ray) (247) – M.P. 908 (469) – S.P. 1100-1200 (675)

Copper (II) fluoride – CuF_2 – 101.57 – Colorless – Monoclinic or Triclinic – D 4.23 (247) – M.P. 950 (1046)

Copper (II) fluoride, hydrate – $CuF_2 \cdot 2H_2O$ – 137.60 – Blue – Monoclinic – D 2.934^{25} (91)

Copper (II) fluoride, acid, hydrate – $CuF_2 \cdot 5HF \cdot 6H_2O$ – 309.70 – Blue – Monoclinic – D 2.405 (469) – R.I. p 1.395, m 1.440, g 1.444 (248)

Copper (II) formate – $Cu(HCO_2)_2$ – 153.61 – Blue – Monoclinic – D 1.831 (469)

Copper (II) hydroxide – $Cu(OH)_2$ – 97.59 – Blue – D 3.368 (675)

Copper (II) nitrate, hydrate – $Cu(NO_3)_2 \cdot 3H_2O$ – 241.63 – Blue – D 2.047 (469) – M.P. 114.49 (469) – D.T. 174 (469)

Copper (II) nitrate, hydrate – $Cu(NO_3)_2 \cdot 6H_2O$ – 295.68 – Pale blue – Rhomboidal – M.P. 26.4 (Incong.) (469)

Copper (I) oxide – Cu_2O (Cuprite) – 143.14 – Red – Cubic – D 6.0 (466) – M.P. 1230 (521) – T.P. 56 (34) – D.T. 1800 (675) – R.I. 2.705 (469)

Copper (II) oxide – CuO (Tenorite or Melaconite) – 79.57 – Black – Monoclinic, Cubic – D 6.35 (869) – M.P. 1447 (521) – R.I. p –, m 2.84, g – (806)

Copper (II) oxide – CuO (Nat. Tenorite) – 79.57 – Black – Triclinic – D 6.45 (617) – D.T. 1026 (153 mm. O_2) (469) – R.I. p –, m 2.63 (red), g – (469)

Copper (II) phosphate, hydrate – $4CuO \cdot P_2O_5 \cdot H_2O$ (Nat. Libethenite) – 478.34 – Olive green – Rhombic – D 3.7 (469) – R.I. p 1.702, m 1.745, g 1.789 (469)

Copper (II) phosphate, hydrate – $4CuO \cdot P_2O_5 \cdot 2H_2O$ (Nat. Pseudolibethenite) – 496.35 – D 4.0 (469)

Copper (II) phosphate, hydrate – $4CuO \cdot P_2O_5 \cdot 3H_2O$ (Nat. Tagilite) – 514.37 – Green – Monoclinic – D 4.08 (469) – R.I. p 1.69, m 1.84, g 1.85 (469)

Copper (II) phosphate, hydrate – $5CuO \cdot P_2O_5 \cdot 2H_2O$ (Nat. Dihydrite) – 575.92 – Green – Monoclinic or Triclinic – D 4.2 (469) – R.I. p 1.719, m 1.762, g 1.805 (469)

Copper (II) phosphate, hydrate – $6CuO \cdot P_2O_5 \cdot 3H_2O$ (Nat. Cornetite) – 673.51 – Greenish blue – Rhombic – D 4.1 (617) – R.I. p 1.765, m 1.81, g 1.82 (617)

Copper (II) selenate, hydrate – $CuO \cdot SeO_3 \cdot 5H_2O$ – 296.61 – Blue – Triclinic – D 2.559 (469)

Copper (I) selenide – Cu_2Se – 206.10 – Dark gray – Cubic – D 6.749^{30} (469) – M.P. 1113 (469) – T.P. 110 (518)

Copper (II) selenide – $CuSe$ (Klockmannite) – 142.53 – Bluish black – Needles – D 6.67 (675)

Copper (II) selenite – $2CuO \cdot SeO_2$ – 270.10 – Yellowish green – Monoclinic – D 4.913^{25} (323)

Copper (II) selenite, hydrate – $CuO \cdot SeO_2 \cdot 2H_2O$ (Chalcomenite) – 306.13 – Blue – Monoclinic, Rhombic – D 3.312^{25} (323) – R.I. p 1.710, m 1.731, g 1.732 (469)

Copper (II) silicate, hydrate – $CuO \cdot SiO_2 \cdot H_2O$ (Nat. Dioptase) – 157.65 – Green – Trigonal – D 3.05 (469) – R.I. o 1.655, e 1.708 (617)

Copper (II) silicate, hydrate – $CuO \cdot SiO_2 \cdot H_2O$ (Nat. Bisbeeite) – 157.65 – Colorless – Rhombic – R.I. p 1.61, m 1.62, g 1.71 (469)

Copper (II) silicate, hydrate – $2CuO \cdot 2SiO_2 \cdot H_2O$ (Nat. Plancheite) – 297.28 – Blue – Monoclinic – D 3.36 (617) – R.I. p 1.645, m 1.660, g 1.715 (617)

Copper (II) silicate, hydrate – $2CuO \cdot 2SiO_2 \cdot H_2O$ (Nat. Shattuckite) – 297.28 – Blue – Monoclinic – R.I. p 1.752, m 1.782, g 1.815 (469)

Copper (II) silicate, fluo-, hydrate – $CuSiF_6 \cdot 6H_2O$ – 313.73 – Blue – Rhombic – D 2.158^{19} (469) – R.I. o 1.409, e 1.408 (469)

Copper (II) silicate, thio- – $4CuS \cdot SiS_2$ – 474.70 – D 4.975 (697) – M.P. 1195 (697)

Copper (II) sulfate – $CuSO_4$ (Hydrocyanite) – 159.63 – Greenish white – Rhombic – D 3.542^{25} (696) – M.P. 200 (469) – D.T. 650 (98) – R.I. p 1.724, m 1.733, g 1.739 (806)

Copper (II) sulfate, oxy- – $CuSO_4 \cdot CuO$ (Dolerophanite) – 239.20 – Brown – Monoclinic – R.I. p –, m 1.777, g – (1075)

Copper (II) sulfate, hydrate – $CuSO_4 \cdot 5H_2O$ (Chalcanthite) – 249.71 – Blue – Monoclinic – D 2.282^{25} (696) – T.P. 29, 35, 53.7 (987) – —H_2O at 96.5, —$2H_2O$ at 102, —$4H_2O$ at 113 (987) – R.I. p 1.5140, m 1.5368, g 1.5434 (806)

Copper (I) sulfide – Cu_2S(I) – 159.20 – Black – Cubic – D 5.76 (270) – M.P. 1127 (521)

Copper (I) sulfide – Cu_2S(II) – 159.20 – Black – Rhombic – D 5.5-5.6 (675) – Transition to I 103 (523)

Copper (II) sulfide – CuS (Covellite) – 95.63 – Black – Hexagonal, Monoclinic – D 4.64^{21} (19) – T.P. 103 (469) – D.T. 358 (in H_2S) (800) – R.I. o 1.45, e – (800) or 2.10-2.15 (211)

Copper (I) telluride – Cu_2Te – 254.75 – T.P. 351, 387 (178)

Dysprosium – Dy – 162.46 – D 8.44 (114)

Dysprosium chloride – $DyCl_3$ – 268.83 – Pale olive green – Plate – D 3.60 (540) – M.P. 654 (491)
Dysprosium oxide – Dy_2O_3 – 372.92 – Colorless – Cubic, Rhombic – D 7.81^{27} (469)
Dysprosium phosphate, hydrate – $Dy_2O_3 \cdot P_2O_5 \cdot 10H_2O$ – 695.12 – Colorless with yellow tint – — $10H_2O > 200$ (492)
Dysprosium selenide – Dy_2Se_3 – 561.80 – Blue black – D ~ 7.72 (551)
Dysprosium sulfate, hydrate – $Dy_2(SO_4)_3 \cdot 8H_2O$ – 757.23 – Yellow – D 3.119^{20} (423) – — $8H_2O$ at 360 (675)
Dysprosium sulfide – Dy_2S_3(I) – 421.10 – Brownish violet – D 6.50 (552)
Dysprosium sulfide – Dy_2S_3(II) – 421.10 – Yellowish brown – D 6.08 (552) – Transition to I 1000 (552)
Erbium – Er – 167.2 – Hexagonal – D 4.8 (689)
Erbium chloride – $ErCl_3$ – 273.57 – Clear red – Plates – D 4.1 (116) – M.P. 774 (491)
Erbium oxide – Er_2O_3 – 382.40 – Red – Cubic – D 8.64 (469) – B.P. 3000 (712)
Erbium selenide – Er_2Se_3 – 571.28 – Ocher yellow and brownish black – D 6.96 (551)
Erbium silicate – $Er_2O_3 \cdot SiO_2$ – 442.46 – Rose color (960)
Erbium sulfate – $Er_2(SO_4)_3$ – 622.58 – Colorless – D 3.678 (469) – D.T. 1000 (668 mm.) (765)
Erbium sulfate, hydrate – $Er_2(SO_4)_3 \cdot 8H_2O$ – 766.71 – Rose red – D 3.205^{20} (424)
Erbium sulfide – Er_2S_3 – 430.6 – Yellowish white – D 6.05^{25} (552) Europium – Eu – 152.0 – Steel gray – D 5.30 (114)
Europium (II) chloride – $EuCl_2$ – 222.91 – Colorless – D 4.87^{27} (50)
Europium (III) chloride – $EuCl_3$ – 258.37 – Colorless – D 4.471^{35} (690) – M.P. 623 (490)
Europium (II) fluoride – EuF_2 – 190.0 – Yellow – Cubic – D 6.495 (55)
Europium (III) oxide – Eu_2O_3 – 352.0 – Colorless with reddish-yellowish tint – Cubic and Rhombic – D 7.42^{15} (469) – T.P. ~ 740 (765)
Europium (II) sulfate – $EuSO_4$ – 248.61 – Rhombic – D 4.985^{23} (667)
Europium (III) sulfate, hydrate – $Eu_2(SO_4)_3 \cdot 8H_2O$ – 736.31 – Pale rose – D 2.972^{20} (1025) – — $8H_2O$ at 375 (675)
Europium (II) sulfide – EuS – 184.06 – Brownish violet – Cubic – D 5.884 (743)
Fluorine – F (F_2) – 19.00 – Yellow gas – M.P. — 223 (14) (1026) – B.P. — 187.17 (15)
Gadolinium – Gd – 156.9
Gadolinium chloride – $GdCl_3$ – 263.27 – Colorless – Monoclinic – D 4.52 (469) – M.P. 609 (491)
Gadolinium formate – $Gd(HCO_2)_3$ – 291.95 – Hexagonal – D 3.8 (758) – R.I. o 1.7379, e 1.7091 (758)
Gadolinium nitrate, hydrate – $Gd(NO_3)_3 \cdot 5H_2O$ – 433.00 – Monoclinic – D 2.406^{15} (469) – M.P. 92 (469)
Gadolinium nitrate, hydrate – $Gd(NO_3)_3 \cdot 6H_2O$ – 451.02 – Triclinic – D 2.332 (469) – M.P. 91 (469)
Gadolinium oxide – Gd_2O_3 – 361.80 – Yellow – Cubic, Rhombic – D 7.407^{15} (469)
Gadolinium selenate – $Gd_2O_3 \cdot 3SeO_3$ – 742.68 – D 4.175^{15} (765)
Gadolinium selenate, hydrate – $Gd_2O_3 \cdot 3SeO_3 \cdot 8H_2O$ – 886.81 – Pearly – Prismatic – D 3.308 (765)
Gadolinium selenate, hydrate – $Gd_2O_3 \cdot 3SeO_3 \cdot 10H_2O$ – 922.84 – Rhombic – D 3.048 (765)
Gadolinium sulfate – $Gd_2(SO_4)_3$ – 601.98 – Colorless – D 4.139^{15} (469)
Gadolinium sulfate, hydrate – $Gd_2(SO_4)_3 \cdot 8H_2O$ – 746.11 – Monoclinic – D 3.010^{15} (469)
Gadolinium sulfide – Gd_2S_3 – 409.98 – Yellow – D 6.16^{25} (552)
Gallium – Ga – 69.72 – Grayish white – Rhombic – D 5.903^{25} (206) – M.P. 29.78 (14) (1026) – B.P. 2071 (15)
Gallium (II) chloride – $GaCl_2$ – 140.63 – Colorless – M.P. 170.5 (626) – B.P. 535 (469)
Gallium (III) chloride – $GaCl_3$ – 176.09 – Colorless – Needle – D 2.47^{25} (556) – M.P. 77.0 (626) – B.P. 200.0 (626)
Gallium (III) fluoride – GaF_3 – 126.72 – D 4.47^{25} (392) – B.P. ~ 1000 (392)
Gallium (I) oxide – Ga_2O – 155.44 – Brownish black – D 4.77^{25} (558) – S.P. 500 (in vac.) (147)
Gallium (III) oxide – Ga_2O_3 – 187.44 – D 5.95 (652)
Gallium (III) oxide – Ga_2O_3(I) – 187.44 – Colorless – Monoclinic or Rhombic – D 5.88^{25} (X-ray) (558) – M.P. 1740 (1052)
Gallium (III) oxide – Ga_2O_3(II) – 187.44 – Colorless – Hexagonal – D 6.44 (X-ray) (1106) – Transition to I 600 (624) – R.I. p 1.92, m –, g 1.95 (624)
Gallium (III) oxide, hydrate – $Ga_2O_3 \cdot H_2O$ – 205.46 – Colorless – Prism – R.I. 1.84 (624)
Gallium (I) selenide – Ga_2Se – 218.40 – Black – D 5.02^{25} (558)

Gallium (II) selenide – GaSe – 148.68 – Dark reddish brown – Plate – D 5.03 (558) – M.P. 960 (558)
Gallium (III) selenide – Ga_2Se_3 – 376.32 – Reddish black – D 4.92^{25} (558) – M.P. $>$ 1020 (558)
Gallium (III) sulfate – $Ga_2(SO_4)_3$ – 427.62 – Colorless – D.T. 690 (760 mm.) (661)
Gallium (I) sulfide – Ga_2S – 171.50 – Black or green – D 4.18^{25} (558)
Gallium (II) sulfide – GaS – 101.78 – Yellow – D 3.86^{25} (558) – M.P. 965 (558)
Gallium (III) sulfide – Ga_2S_3 – 235.62 – Yellow – D 3.65^{25} (558) – M.P. 1255 (in vac.) (146)
Gallium (II) telluride – GaTe – 197.33 – Black – Leaflet – D 5.44^{25} (558) – M.P. 824 (558)
Gallium (III) telluride – Ga_2Te_3 – 522.27 – Black – D 5.57^{25} (558) – M.P. 790 (558)
Germanium – Ge – 72.60 – Grayish white – Cubic – D 5.36^{20} (15) – M.P. 958 (14) (1026) – B.P. 2700 (15)
Germanium chloride – $GeCl_4$ – 214.43 – Colorless – Liquid – D 1.879^{20} (627) – M.P. —49.5 (469) – B.P. 84 (519) – R.I. 1.4638^{20} (627)
Germanium fluoride – GeF_4 – 148.60 – Colorless, gas – D 3.148^{-195} (283) – M.P. —15 (3032 mm.) (226) – S.P. —35 (283)
Germanium (II) oxide – GeO – 88.60 – Yellow – D 1.825^{21} (920) – S.P. 710 (in N_2) (225)
Germanium oxide – GeO_2(I) (Soluble form) – 104.60 – Colorless – Hexagonal – D 4.228^{25} (625) – M.P. 1116 (625) – R.I. o 1.695, e 1.735 (625)
Germanium oxide – GeO_2(II) (Insoluble form) – 104.60 – Colorless – Tetragonal – D 6.239^{25} (625) – M.P. 1086 (625) – Transition to I 1033 (625) – R.I. o 1.99, e 2.05-2.10 (625)
Germanium oxide – GeO_2 (Glass) – 104.60 – Colorless – D 3.6277^{20} (703) – R.I. 1.6069 (703)
Germanium (II) selenide – GeSe – 151.56 – Tetragonal – D 5.30^{25} (475) – M.P. 667 (475)
Germanium selenide – $GeSe_2$ – 230.52 – Rhombic – D 4.56^{25} (475) – M.P. 707 (475)
Germanium sulfate – $Ge(SO_4)_2$ – 264.72 – Colorless – D 3.92^{22} (922) – Decomposition begins 200 (922)
Germanium (II) sulfide – GeS – 104.66 – Black – Crystalline – D 3.78^{20} (225) – M.P. 625 (225)
Germanium (II) sulfide – GeS – 104.66 – Dark red – Amorphous – D 3.31^{20} (225)
Germanium (IV) sulfide – GeS_2 – 136.72 – Colorless – Rhombic – D 2.942^{14} (811) – M.P. 800 (811)
Germanium sulfide – GeS_2 (Glass) – 136.72 – Amber color, transparent – D 5.81 (811)
Germanium (II) telluride – GeTe – 200.21 – Metallic color – D 6.20^{25} (548) – M.P. 725 (Incong.) (548)
Gold – Au – 197.2 – Yellow – Cubic – D 19.3^{20} (15) – M.P. 1063.0 (14) (1026) – B.P. 2966 (15)
Gold (I) chloride – AuCl – 232.66 – Yellow – D 7.8^{25} (67) – D.T. 289.5 (469)
Gold (III) chloride – $AuCl_3$ – 303.57 – Red – Needle-like – D 4.67^{25} (279) – D.T. 254 (469) – S.P. 265 (469)
Gold (I) cyanide – AuCN – 223.22 – Light yellow – D 7.122^{25} (68)
Gold (I) oxide – Au_2O – 410.4 – Dark violet – D.T. 205 (469)
Gold (III) oxide – Au_2O_3 – 442.40 – Brownish black – D.T. 160 (469)
Gold (III) selenide – Au_2Se_3 – 631.28 – Black – D 4.65 (469)
Gold (III) sulfide – Au_2S_3 – 490.58 – Black – D 8.754 (469) – D.T. 197 (469)
Gold (II) telluride – AuTe (Nat. Calaverite) – 324.81 – Trigonal – D 9.04 (469)
Gold telluride, di- – Au_2Te_4 (Nat. Krennerite) – 904.84 – Rhombic – D 9.31 (X-ray) (1020) – M.P. 472 (469)
Hafnium – Hf – 178.6 – Hexagonal – D 11.4^{20} (15) – M.P. 1700 (14) (1026) – B.P. 5393 (15)
Hafnium chloride – $HfCl_4$ – 320.43 – M.P. 432 (282) – S.P. 317 (282)
Hafnium fluoride – HfF_4 – 254.6 – Monoclinic – D 7.13 (X-ray) (910) – R.I. p 1.54, m 1.58, g – (425)
Hafnium oxide – HfO_2 – 210.6 – D 9.68 (469) – M.P. 2812 (469)
Hafnium phosphate – $HfO_2 \cdot P_2O_5$ – 352.64 – Colorless – Cubic – D 4.278 (639)
Holmium – Ho – 164.94 – Hexagonal – D 8.76 (X-ray) (113)
Holmium chloride – $HoCl_3$ – 271.31 – Yellow – D 4.25 (540) – M.P. 718 (491)
Holmium oxide – Ho_2O_3 – 377.88 – Pale yellow – Cubic – D 8.36 (X-ray) (1106)
Holmium sulfate, hydrate – $Ho_2(SO_4)_3 \cdot 8H_2O$ – 762.19 – Red – Monoclinic – D 3.149^{20} (423)
Hydrogen – $H(H_2)$ – 1.0080 (1.00775 for H^1) (36) – Colorless gas – D 0.0890^{-269} (Solid) (671) – M.P. —259.2 (14) (1026) – B.P. —252.754 (15) – R.I. $1.112^{B.P.}$ (Lambda = 5461) (498)
Hydrogen, para- – H (Para-H_2) – 1.0080 – Colorless gas – B.P. —252.82 (519)
Hydrogen, heavy – HD – 3.0216 – Colorless gas – M.P. —256.5 (14) (1026)
Hydrogen, heavy – D (D_2) – 2.01363 (36) – Colorless gas – D 0.2059^{-269} (Solid) (671) – M.P. —254.5 (14) (1026)

Hydrogen chloride – HCl – 36.465 – Colorless gas – D $1.194^{-85.8}$ (469) – M.P. — 114.19 (521) – T.P. — 174.2 (348) – B.P. — 85 (519)

Hydrogen cyanide – HCN – 27.026 – Colorless liquid – D 0.6950^{15} (302) – M.P. —14.2 (641) – B.P. 23.5 (645)

Hydrogen fluoride – H_2F_2 – 40.02 – Colorless liquid – D 1.0005^{0} (431) – M.P. — 83.7 (162) – B.P. 19.54 (301)

Hydrogen selenide – H_2Se – 80.98 – Colorless gas – D 1.961^{-27} (Liquid) (848) – M.P. — 65.74 (596) – T.P. — 100.63, — 190.9 (596) – B.P. — 41.3 (519)

Hydrogen sulfide – H_2S – 34.076 – Colorless gas – D 0.9714^{-78} (Liquid) (541) 1.217^{-195} (Solid) (88) – M.P. — 85.57 (596) – T.P. — 146.93, — 169.60 (596) – B.P. — 60.3 (519) – R.I. 1.374 (Liquid) (469)

Hydrogen telluride – H_2Te – 129.63 – Colorless gas – D $2.701^{-17.7}$ (Liquid) (848) – M.P. — 48.9 (521) – B.P. — 2.2 (519)

Indium – In – 114.76 – Silvery – Cubic – D 7.31^{20} (15) – M.P. 156.4 (14) (1026) – B.P. > 1450 (15)

Indium (III) borate – $In_2O_3 \cdot B_2O_3$ – 347.16 – Colorless or slight yellow – Hexagonal – D 5.576 (X-ray) (352) – R.I. $^{o}_{e} > 1.74$ (352)

Indium (I) chloride – $InCl$(I) – 150.22 – Red – D 4.18^{25} (I and II) (547) – M.P. 225 (610) – B.P. 608 (843)

Indium (I) chloride – $InCl$(II) – 150.22 – Yellow – D 4.19^{25} (610) – Transition to I at 120 (610)

Indium (II) chloride – $InCl_2$ – 185.67 – Colorless – Rhombic – D 3.655^{25} (547) – M.P. 235 (5) – B.P. 570 (5)

Indium (III) chloride – $InCl_3$ – 221.13 – D 3.45 (547) – M.P. 586 (610) – S.P. 498 (843)

Indium (III) fluoride – InF_3 – 171.76 – D 4.39 (392) – M.P. 1170 (392) – B.P. > 1200 (392)

Indium (I) oxide – In_2O – 245.52 – Black – D 6.99 (558) – S.P. 675 (High Vac.) (991)

Indium (III) oxide – In_2O_3 – 277.52 – Yellow – Trigonal – D 7.04^{25} (558) – M.P. ~ 2000 (558)

Indium (I) selenide – In_2Se – 308.48 – Black – D 6.17^{25} (558)

Indium (II) selenide – $InSe$ – 193.72 – Black – D 5.55^{25} (558) – M.P. 660 (558)

Indium (III) selenide – In_2Se_3 – 466.40 – Black – D 5.67^{25} (558) – M.P. 890 (558)

Indium (III) sulfate – $In_2(SO_4)_3$ – 517.70 – Colorless – D 3.438 (469) – D.T. 810 (760 mm.) (927)

Indium (I) sulfide – In_2S – 261.58 – Dark brown – D 5.87^{25} (558) – M.P. 653 (991)

Indium (II) sulfide – InS – 146.82 – Red brown – D 5.18 (558) – M.P. 692 (558)

Indium (III) sulfide – In_2S_3 – 325.70 – Black or red – D 4.89 (558) – M.P. 1050 (558)

Indium (I) telluride – In_2Te – 357.13 – Black – D 6.47^{25} (558)

Indium (II) telluride – $InTe$ – 242.37 – Steel blue – D 6.29^{25} (558) – M.P. 696 (558)

Indium (III) telluride – In_2Te_3 – 612.35 – Black – D 5.75^{25} (558) – M.P. 667 (558)

Iodine – I – 126.92 – Grayish black – Rhombic – D 4.93^{20} (15) – M.P. 114 (14) (1026) – B.P. 184.3 (15)

Iodine (V) oxide – I_2O_5 – 333.84 – Colorless – D 4.80^{25} (49)

Iridium – Ir – 193.1 – White – Cubic – D 22.4^{20} (15) – M.P. 2454 (14) (1026) – B.P. 4900 (15)

Iridium (II) chloride – $IrCl_2$ – 264.01 – Black green – Hexagonal or Trigonal – D.T. 773 (469)

Iridium (VI) fluoride – IrF_6 – 307.10 – Pale yellow – Tetragonal – D 6.0^{-190} (878) – B.P. 53 (878)

Iridium (VI) selenide – $IrSe_3$ – 429.98 – D 8.05 (72)

Iron – Fe – 55.85 – Silver white – Cubic – D 7.87 (15) – M.P. 1539 (851) – T.P. 909.5 (1062) – B.P. 2999 (15)

Iron (II) aluminate – $FeO \cdot Al_2O_3$ (Hercynite) – 173.78 – Colorless – Cubic – D 4.35 (1078) – M.P. 1440 (Incong.) (668) – R.I. 1.83 (1078)

Iron (II) aluminate – $3FeO \cdot Al_2O_3$ – 317.46 – M.P. 1225 (Incong.) (668)

Iron (II) aluminum silicate – $3FeO \cdot Al_2O_3 \cdot 3SiO_2$ (Nat. Almandite) – 497.64 – Cubic – D 4.04 (469) – M.P. 1180 (1118) – R.I. 1.830 (1076)

Iron (II) antimonate – $2FeO \cdot Sb_2O_5$ (Nat. Tripuhyite) – 467.20 – Greenish yellow – D 5.82 (469) – R. I. p 2.19, m 2.20, g 2.33 (469)

Iron (III) arsenate – $Fe_2O_3 \cdot As_2O_5$ – 389.50 – Brown – Monoclinic – D 4.32 (1075) – R.I. p –, m 1.78, g – (1075)

Iron (II) carbonate – $FeCO_3$ (Siderite) – 115.85 – Brown – Trigonal – D 3.832 (71) – D.T. 186 (760 mm.) (520) – R.I. o 1.875, e 1.633 (469)

Iron (II) chloride – $FeCl_2$ (Lawrencite) – 126.75 – Green – Hexagonal – D 3.162 (75) – M.P. 677 (521) – B.P. 1026 (519) – R.I. o 1.57, e – (469)

Iron (III) chloride – Fe_2Cl_6 (Molysite) – 324.42 – Brownish yellow – Hexagonal – D 2.904^{17} (457) – M.P. 304 (521) – B.P. 319 (519)

Iron (II) chromate – $FeO \cdot Cr_2O_3$ (Chromite) – 223.86 – Black – Cubic – D 5.08 (1078) – M.P. 1850 (148) – R.I. 2.16 (469)

Iron (II) columbate – $FeO \cdot Cb_2O_5$ (Nat. Ferroniobite) – 337.66 – Rhombic – D 6.26 (469) – R. I. p –, m 2.40 (Li line), g – (469)

Iron (II) fluoride – FeF_2 – 93.84 – Colorless – Tetragonal – D 3.95 (874) – M.P. $>$ 1000 (91)

Iron (III) fluoride – FeF_3 – 112.84 – Greenish – Triclinic – D 3.52 (874)

Iron (II) fluoride, hydrate – $FeF_2 \cdot 4H_2O$ – 165.90 – D 2.095^{25} (91)

Iron (III) fluoride, hydrate – $FeF_3 \cdot 3H_2O$ – 166.89 – Tetragonal – D 2.26 (733) – R.I. o 1.489, e 1.454 (733)

Iron (III) fluoride, hydrate – $FeF_3 \cdot 3H_2O$ – 166.89 – Rhombohedral – D 2.20 (733) – R.I. o 1.452, e 1.495 (733)

Iron (III) nitrate, hydrate – $Fe(NO_3)_3 \cdot 6H_2O$ – 349.96 – Colorless – Cubic – M.P. 35 (469)

Iron (II) oxide – FeO (Wuestite) – 71.84 – Grayish blue – Cubic – D 5.745^{25} (861) – M.P. 1380 (Incong.) (521) – R.I. 2.32 (128)

Iron (II, III) oxide – Fe_3O_4 (Magnetite) – 231.52 – Reddish black – Cubic – D 5.125^{18} (611) – M.P. 1590 (456) – R.I. 2.42 (649)

Iron (III) oxide – Fe_2O_3 (Hematite) – 159.68 – Red – Hexagonal – D 5.200^{15} (868) – M.P. 1548-1560 (Incong.) (469) – T.P. 678 (950), 1030 (259) – R.I. o 3.01, e 2.78 (683)

Iron (III) oxide – Fe_2O_3 (Gamma) – 159.68 – D 4.59 (387)

Iron (III) oxide – Fe_2O_3 (Delta) – 159.68 – D 4.7 (345)

Iron (III) oxide, hydroxy- – FeO(OH) (Goethite) – 88.85 – Red – Rhombic – D 4.28 (469) – — $1/2H_2O$ at 136 (1065) – R.I. p 2.260, m 2.394, g 2.400 (804)

Iron (III) oxide, hydroxy- – FeO(OH) (Nat. Lepidocrocite) – 88.85 – Red – Rhombic – D 409 (469) – D.T. 300-400 (354) – R.I. p 1.94, m 2.20, g 2.51 (469)

Iron (II) oxide, hydrate – $FeO \cdot H_2O$ – 89.86 – Greenish white – D 3.40 (721)

Iron (II) phosphate, ortho- – $3FeO \cdot P_2O_5$(I) – 357.56 – Colorless – M.P. 1238 (1069)

Iron (II) phosphate, ortho- – $3FeO \cdot P_2O_5$(II) – 357.56 – Gray – Transition to I 942 (1069)

Iron (III) phosphate, ortho- – $Fe_2O_3 \cdot P_2O_5$(I) – 301.72 – Dark gray – Tabular prism – M.P. 1240 (1069)

Iron (III) phosphate, ortho- – $Fe_2O_3 \cdot P_2O_5$(II) – 301.72 – Gray – Transition to I 889 (1069)

Iron (III) phosphate, ortho- – $Fe_2O_3 \cdot P_2O_5$(III) – 301.72 – Colorless – Needle – D 3.1 (163) – Transition to II 789 (1069)

Iron (III) phosphate, meta- – $Fe_2O_3 \cdot 3P_2O_5$ – 585.80 – Colorless – Rhombic – D 3.02 (469)

Iron (III) phosphate – $2Fe_2O_3 \cdot 3P_2O_5$(I) – 745.48 – M.P. 1270 (1069)

Iron (III) phosphate – $2Fe_3O_2 \cdot 3P_2O_5$(II) – 745.48 – Transition to I 865 (1069)

Iron (II) phosphate, hydrate – $3FeO \cdot P_2O_5 \cdot 8H_2O$ (Nat. Vivianite) – 501.69 – Monoclinic – D 2.58 (469) – R.I. p 1.579, m 1.603, g 1.633 (469)

Iron (II) phosphate, hydrate – $7FeO \cdot 2P_2O_5 \cdot 9H_2O$ (Nat. Ludlamite) – 949.11 – Monoclinic – D 3.72 (469) – R.I. p 1.653, m 1.675, g 1.697 (617)

Iron (III) phosphate, hydrate – $Fe_2O_3 \cdot P_2O_5 \cdot 4H_2O$ (Nat. Strengite) – 373.78 – Rhombic – D 2.87 (469) – R.I. p 1.708, m 1.708, g 1.745 (617)

Iron (III) phosphate, hydrate – $Fe_2O_3 \cdot P_2O_5 \cdot 6H_2O$ (Nat. Koninckite) – 409.82 – Rhombic – D 2-3 (617) – R.I. p –, m 1.58, g – (617)

Iron (III) phosphate, hydrate – $2Fe_2O_3 \cdot P_2O_5 \cdot 3H_2O$ (Nat. Dufrenite) – 515.45 – Dull leaf green – Monoclinic – D 3.3 (617) – R.I. p 1.830, m 1.840, g 1.885 (469)

Iron (III) phosphate, hydrate – $2Fe_2O_3 \cdot P_2O_5 \cdot 12H_2O$ (Nat. Cacoxenite) – 677.59 – Hexagonal – D 3.38 (469) – R.I. o 1.582, e 1.645 (469)

Iron (III) phosphate, hydrate – $2Fe_2O_3 \cdot 2P_2O_5 \cdot 7H_2O$ (Nat. Phosphosiderite) – 731.55 – Rhombic – D 2.724 (617) – R.I. p 1.692, m 1.725, g 1.738 (617)

Iron (III) phosphate, hydrate – $3Fe_2O_3 \cdot 2P_2O_5 \cdot 8H_2O$ (Nat. Beraunite) – 907.25 – Monoclinic – D 2.9 (469) – R.I. p 1.775, m 1.786, g 1.815 (469)

Iron (II) selenide – FeSe – 134.81 – Dark gray – Tetragonal, Hexagonal, Monoclinic – D 6.78 (X-ray) (1097)

Iron (III) selenide – Fe_2Se_3 – 348.58 – Grayish yellow – D 6.38 (646)

Iron (II) silicate, meta- – $FeO \cdot SiO_2$ (Gruenerite) – 131.90 – Grayish green – Monoclinic – D 3.44 (960) – M.P. 1146 (1061) – R.I. p 1.672, m 1.697, g 1.717 (469)

Iron (II) silicate, ortho- – $2FeO \cdot SiO_2$ (Fayalite) – 203.74 – Greenish brown – Rhombic – D 4.241^{20} (865) – M.P. 1205 (128) – R.I. p 1.824, m 1.864, g 1.875 (128)

Iron (II) silicate, hydrate – $3FeO \cdot 4SiO_2 \cdot 2H_2O$ (Nat. Greenalite) – 491.79 – Green – Cubic – D 3.0 (504) – R.I. 1.675 (504)

Iron (II) silicate, hydrate – $7FeO \cdot 8SiO_2 \cdot H_2O$ (Nat. Gruenerite) – 1001.38 – Greenish gray – D 3.597 (127) – R.I. p 1.686, m 1.709, g 1.729 (127)

Iron (II, III) silicate, hydrate – $9FeO \cdot Fe_2O_3 \cdot 8SiO_2 \cdot 8H_2O$ (Nat. Greenite) – 1430.85 – R.I. ∼ 1.670 (449)

Iron (III) silicate, hydrate – $Fe_2O_3 \cdot 2SiO_2 \cdot 4H_2O$ (Nat. Canbyite) – 351.86 – Amber brown – R.I. p 1.562, m 1.580, g 1.582 (617)

Iron (III) silicate, hydrate – $2Fe_2O_3 \cdot 2SiO_2 \cdot 3H_2O$ (Nat. Iddingsite) – 493.53 – Rhombic – D 2.8 (469) – R.I. p 1.71, m 1.74, g 1.76 (469)

Iron (II) silicate, fluo-, hydrate – $FeF_2 \cdot SiF_4 \cdot 6H_2O$ – 306.00 – Bluish green – Trigonal – R.I. o 1.3638, e 1.3848 (469)

Iron (II) silicate fluoride – $6FeO \cdot 8SiO_2 \cdot FeF_2$ – 1005.36 – R.I. p 1.665, m 1.676, g 1.690 (127)

Iron (II) sulfate – $FeSO_4$ – 151.90 – Colorless – D 3.346 (996)

Iron (III) sulfate – $Fe_2(SO_4)_3$ – 399.86 – Light yellowish red – Rhombic – D 3.02 (530) – B.P. 707 (715 mm.) (1081) – R.I. p 1.802, m 1.814, g 1.818 (805)

Iron (III) sulfate – $Fe_2(SO_4)_3$ – 399.86 – Yellow – Hexagonal – D 3.23 (565) – R.I. o 1.770, e 1.760 (805)

Iron (II) sulfate, hydrate – $FeSO_4 \cdot H_2O$ (Szomolnikite) – 169.92 – Monoclinic – D 2.970^{25} (696)

Iron (II) sulfate, hydrate – $FeSO_4 \cdot 4H_2O$ – 223.96 – Greenish white – Monoclinic – D 2.293^{25} (696) – R.I. p 1.533, m 1.535, g – (612)

Iron (II) sulfate, hydrate – $FeSO_4 \cdot 5H_2O$ (Nat. Siderotil) – 241.98 – Greenish white – Triclinic – D 2.2 (469) – R.I. p 1.528, m 1.537, g 1.543 (469)

Iron (II) sulfate, hydrate – $FeSO_4 \cdot 7H_2O$ (Melanterite) – 278.01 – Greenish white – Monoclinic – D 1.895^{25} (696) – M.P. 64 (1003) – R.I. p 1.4713, m 1.4782, g 1.4856 (469)

Iron (II) sulfate, hydrate – $FeSO_4 \cdot 7H_2O$ (Tauriseite) – 278.01 – Rhombic – D 1.875 (834)

Iron (III) sulfate, hydrate – $Fe_2(SO_4)_3 \cdot 4H_2O$ – 471.92 – R.I. p –, m 1.533, g 1.535 (611)

Iron (III) sulfate, hydrate – $Fe_2(SO_4)_3 \cdot 6H_2O$ – 507.96 – Colorless – Monoclinic – R.I. p 1.605, m 1.635, g 1.657 (805)

Iron (III) sulfate, hydrate – $Fe_2(SO_4)_3 \cdot 7H_2O$ – 525.98 – Colorless to pink – Monoclinic – R.I. p 1.572, m 1.586, g 1.640 (805)

Iron (III) sulfate, hydrate – $Fe_2(SO_4)_3 \cdot 9H_2O$ – 562.01 – Yellow – Hexagonal – D 2.1 (469) – R.I. o 1.552, e 1.558 (469)

Iron (II) sulfide – FeS(I) (Troilite) – 87.90 – Rhombic – D 4.787 (348) – M.P. 1195 (521)

Iron (II) sulfide – FeS(II) (Magnetkies) – 87.90 – Dark brown – Hexagonal – D 4.764^{25} (512) – Transition to I 138 (523)

Iron (III) sulfide – Fe_2S_3 – 207.86 – Grayish yellow – D 4.3 (469)

Iron sulfide – FeS_2 (Artificial Pyrite) – 119.96 – D 5.01 (512) – D.T. 440 (523)

Iron sulfide – FeS_2 (Pyrite) – 119.96 – Yellow – Cubic – D 4.911 (7)

Iron sulfide – FeS_2 (Nat. Marcasite) – 119.96 – Rhombic – D 4.5-4.9 (348)

Iron (II) tantalate – $FeO \cdot Ta_2O_5$ (Nat. Tapiolite) – 513.60 – Light brown – Tetragonal – D 7.33 (173) – R.I. o ∼ 2.27, e ∼ 2.42 (Li line) (617)

Iron (II) titanate – $FeO \cdot TiO_2$ (Ilmenite) – 151.74 – Black – Trigonal – D 4.75 (469) – M.P. 1470 (368) – T.P. 215 (562)

Iron (II) titanate – $2FeO \cdot TiO_2$ (Pseudobrookite) – 223.58 – Red – Rhombic – D 4.37 (403) – M.P. 1470 (368)

Iron (III) titanate – $Fe_2O_3 \cdot 3TiO_2$ (Nat. Arizonite) – 399.38 – Monoclinic – D 4.25 (469) – R.I. p –, m 2.62, g – (469)

Iron (III) titanate – $2Fe_2O_3 \cdot 3TiO_2$ (Nat. Pseudobrookite) – 559.06 – Rhombic – D 4.7 (469) – R.I. p 2.38, m 2.39, g 2.42 (469)

Iron (II) titanite – $FeO \cdot Ti_2O_3$ – 215.64 – Black – D 4.346^{21} (589)

Iron (II) tungstate – $FeO \cdot WO_3$ (Nat. Ferberite) – 303.76 – Tetragonal – D 6.64 (469) – R.I. p –, m 2.40 (Li), g – (469)

Lanthanum – La – 138.92 – White – Hexagonal – D 6.15^{20} (15) – M.P. 826 (14) (1026) – B.P. 1800 (15)

Lanthanum borate – $La_2O_3 \cdot B_2O_3$ – 395.48 – Colorless – Rhombic – D 5.339 (X-ray) (352)

Lanthanum chloride – $LaCl_3$ – 245.29 – Colorless – Needle – D 3.82 (540) – M.P. 872 (540) – B.P. > 1000 (1034)

Lanthanum fluoride – LaF_3 – 195.92 – Colorless – Cubic – D 4.49^{15} (53)

Lanthanum germanate – $La_2O_3 \cdot GeO_2$ – 430.44 – Rhombic (342)

Lanthanum molybdate – $La_2O_3 \cdot 3MoO_3$ – 757.69 – Tetragonal – D 4.77^{16} (469) – M.P. 1181 (469)
Lanthanum nitrate, hydrate – $La(NO_3)_3 \cdot 6H_2O$ – 433.04 – Colorless – Triclinic – M.P. 66.5 (816) – T.P. 43 (311)
Lanthanum oxide – La_2O_3 – 325.84 – Colorless – Trigonal – D 6.51 (469) – M.P. 2315 (1052) – B.P. $\sim$ 4200 (712)
Lanthanum phosphate – $La_2O_3 \cdot P_2O_5$ – 467.88 – Colorless – Monoclinic
Lanthanum phosphate – $La_2O_3 \cdot 5P_2O_5$ – 1036.04 – Monoclinic – D 3.241 (469)
Lanthanum selenide – La_2Se_3 – 514.72 – Brick red – D 6.1 (551)
Lanthanum selenide – La_2Se_4 – 593.68 – D 6.32 (551)
Lanthanum silicate – $La_2O_3 \cdot SiO_2$ – 385.90 – Colorless – Hexagonal (341)
Lanthanum silicate – $La_2O_3 \cdot 2SiO_2$ – 445.96 – Colorless – Tetragonal and Monoclinic (341) – Melt Incong.
Lanthanum sulfate – $La_2(SO_4)_3$ – 566.02 – Colorless – D 3.600 (469) – D.T. 1120 (430 mm.) (765)
Lanthanum sulfate, hydrate – $La_2(SO_4)_3 \cdot 9H_2O$ – 728.17 – Colorless – Hexagonal – D 2.821 (469) – R.I. o 1.564, e 1.569 (Red) (609)
Lanthanum sulfide – La_2S_3 – 374.02 – Yellow – Hexagonal – D 4.86^{25} (552) – M.P. 2125 (in vac.) (793)
Lanthanum sulfide – La_2S_4 – 406.08 – D 4.76^{25} (552) – D.T. 650 (469)
Lead – Pb – 207.21 – Bluish white – Cubic – D 11.34 (15) – M.P. 327.4 (14) (1026) – B.P. 1744 (15)
Lead aluminate, thio- – $PbS \cdot Al_2S_3$ – 389.19 – Rose yellow – D 4.431^{25} (699) – M.P. 860 (699)
Lead aluminate, thio- – $2PbS \cdot Al_2S_3$ – 628.46 – Dark yellow – D 5.886^{25} (699) – M.P. 751 (699)
Lead aluminum antimonate – $2PbO \cdot Al_2O_3 \cdot Sb_2O_5$ – 871.88 – Light yellow – D 7.2 (969)
Lead antimonate, meta- – $PbO \cdot Sb_2O_5$ – 546.73 – Colorless – D 6.8 (969)
Lead antimonate, pyro- – $2PbO \cdot Sb_2O_5$ – 769.94 – Yellow – Cubic – D 8.0 (969)
Lead antimonate, ortho- – $3PbO \cdot Sb_2O_5$ (Nat. Monimolite) – 993.15 – Dark orange yellow – D 6.58 (469)
Lead antimonite – $PbO \cdot Sb_2O_3$ – 514.73 – M.P. 558 (657)
Lead antimonite, thio- – $PbS \cdot Sb_2S_3$ (Nat. Zinkenite) – 578.97 – Rhombic – D 5.3 (469) – S.P. 475 (469)
Lead antimonite, thio- – $2PbS \cdot Sb_2S_3$ (Nat. Plumosite) – 818.24 – Monoclinic – D 5.62 (469)
Lead antimonite, thio- – $3PbS \cdot Sb_2S_3$ – 1057.51 – Gray – Rhombic or Monoclinic – D 6.17 (474)
Lead antimonite, thio- – $5PbS \cdot 2Sb_2S_3$ (Nat. Boulangerite) – 1875.75 – Monoclinic – D 6.23 (63)
Lead arsenate, meta- – $PbO \cdot As_2O_5$ – 453.03 – Hexagonal – D 6.42 (469)
Lead arsenate, pyro- – $2PbO \cdot As_2O_5$ – 676.24 – Rhombic – D 6.85 (469) – M.P. 802 (469) – R.I. p –, m 2.03, g – (469)
Lead arsenate, ortho- – $3PbO \cdot As_2O_5$ – 899.45 – Yellow white – D 7.30 (469) – M.P. 1042 (469) – R.I. 2.14 (675)
Lead arsenate – $8PbO \cdot As_2O_5$ – 2015.50 – M.P. 862 (469)
Lead arsenate, hydrate – $PbO \cdot As_2O_5 \cdot 2H_2O$ – 489.06 – Triclinic – D 4.46 (469) – D.T. 140 (469) – R.I. p 1.74, m 1.82, g – (469)
Lead arsenate, hydrate – $2PbO \cdot As_2O_5 \cdot H_2O$ (Nat. Schultenite) – 694.26 – Colorless – Monoclinic – D 5.79 (469) – M.P. $>$ 200 (469) – R.I. p 1.90, m 1.91, g 1.97 (469)
Lead arsenate, hydrate – $6PbO \cdot 2As_2O_5 \cdot H_2O$ – 1816.92 – D 7.00 (469)
Lead arsenite – $PbO \cdot As_2O_3$ – 421.03 – White – D 5.85 (469)
Lead arsenite, thio- – $PbS \cdot As_2S_3$ (Nat. Sartorite) – 485.27 – Rhombic – D 4.6 (469) – D.T. $<$ 700 (469)
Lead arsenite, thio- – $2PbS \cdot As_2S_3$ (Nat. Dufrenoysite) – 724.54 – Rhombic – D 5.50 (469)
Lead arsenite, thio- – $3PbS \cdot 2As_2S_3$ (Nat. Baumhauerite) – 1209.81 – Monoclinic – D 5.43 (X-ray) (777)
Lead bismuthite – $2PbO \cdot Bi_2O_3$ – 912.42 – M.P. 625 (58)
Lead bismuthite – $2PbO \cdot 3Bi_2O_3$ – 1844.42 – M.P. 686 (58)
Lead borate – $PbO \cdot 2B_2O_3$ – 362.49 – M.P. 768 (326) – R.I. p 1.915, m –, g 1.935 (326)
Lead borate – $2PbO \cdot B_2O_3$(I) – 516.06 – M.P. 497 (Incong.) (326) – R.I. p 1.965, m –, g 2.025 (326)
Lead borate – $2PbO \cdot B_2O_3$(II) – 516.06 – Transition to I at 473 (326) – R.I. p 2.08, m 2.10, g 2.11 (326)
Lead borate – $4PbO \cdot B_2O_3$(I) – 962.48 – M.P. 565 (326) – R.I. p 2.15, m –, g 2.20 (326)
Lead borate – $4PbO \cdot B_2O_3$(II) – 962.48 – M.P. 555 (326) – R.I. p 2.15, m 2.20, g 2.24 (326)

Lead borate – $5PbO \cdot 4B_2O_3$ – 1394.61 – M.P. 548 (Incong.) (326) – R.I. p 1.91, m 1.93, g 1.96 (326)

Lead carbonate – $PbCO_3$ (Cerussite) – 267.22 – Colorless – Rhombic – D 6.533^{20} (21) – D.T. 293 (760 mm.) (520) – R.I. p 1.804, m 2.076, g 2.078 (469)

Lead carbonate, hydroxy- – $Pb_3(OH)_2(CO_3)_2$ (Hydrocerussite) – 775.67 – Colorless – Hexagonal – D 6.73 (71) – R.I. o 2.09, e 1.94 (469)

Lead carbonate, oxy- – $PbO \cdot PbCO_3$ – 490.43 – D.T. 322 (766 mm.) (520)

Lead chlorate – $Pb(ClO_3)_2$ – 374.12 – Colorless – Monoclinic – D 389 (469)

Lead chloride – $PbCl_2$ (Cotunnite) – 278.12 – Colorless – Rhombic – D 5.909^{18} (864) – M.P. 498 (521) – B.P. 954 (519) – R.I. p 2.1992, m 2.2172, g 2.2596 (469)

Lead (IV) chloride – $PbCl_4$ – 349.04 – Yellowish liquid – D 3.18 (Liq.) (469) – M.P. –15 (469) – B.P. 105 (469)

Lead chloride fluoride – PbClF (Nat. Matlockite) – 261.67 – Tetragonal – D 7.05 (40) – M.P. 601 (469) – R.I. o 2.145, e 2.006 (40)

Lead chloride oxide – $PbO \cdot PbCl_2$ (Nat. Matlockite?) – 501.33 – Colorless – Tetragonal – D 7.21 (469) – D.T. 524 (469) – R.I. p 2.04, m 2.15, g 2.15 (469)

Lead chloride oxide – $PbO \cdot 2PbCl_2$ (Nat. Penfieldite) – 724.54 – Yellow – Hexagonal – R.I. o 2.13, e 2.21 (469)

Lead chloride oxide – $2PbO \cdot PbCl_2$ (Nat. Mendipite) – 724.54 – Rhombic – D 7.08 (469) – M.P. 693 (469) – R.I. p 2.24, m 2.27, g 2.31 (469)

Lead chloride oxide – $4PbO \cdot PbCl_2$ – 1170.96 – Yellow – Tabular – M.P. 711 (867)

Lead chloride oxide – $6PbO \cdot PbCl_2$ (Nat. Lorettoite) – 1617.38 – Tetragonal – D 7.6 (469) – R.I. o 2.35 (Li-line), e 2.33 (Li-line) (469)

Lead chromate – $PbO \cdot CrO_3$(I) – 323.22 – Tetragonal – M.P. 844 (479)

Lead chromate – $PbO \cdot CrO_3$(II) – 323.22 – Rhombic – Transition to I 783 (479)

Lead chromate – $PbO \cdot CrO_3$(III) (Crocoite) – 323.22 – Monoclinic – D 6.3 (469) – Transition to II 707 (479) – R.I. p 2.31, m 2.37 (Li-line), g 2.66 (469)

Lead chromate – $3PbO \cdot 2CrO_3$ (Nat. Phoenicochroite) – 869.65 – Rhombic – D 5.75 (469) – R.I. p 2.34, m 2.38, g 2.65 (All for Li-line) (617)

Lead chromate – $7PbO \cdot 2CrO_3$ – 1762.49 – M.P. 854 (479) – T.P. 744 (479)

Lead chromate – $2PbO \cdot CrO_3$ – 546.43 – M.P. 920 (479)

Lead copper phosphate – $4PbO \cdot CuO \cdot P_2O_5$ (Nat. Tsumebite) – 1114.45 – Rhombic – D 6 (469) – R.I. p 1.885, m 1.920, g 1.956 (469)

Lead cyanate, thio- – $Pb(SCN)_2$ – 323.37 – Colorless – Monoclinic – D 3.82 (469)

Lead ferrite – $PbO \cdot Fe_2O_3$ – 382.89 – M.P. 1530 (25)

Lead ferrite – $PbO \cdot 6Fe_2O_3$ – 1181.29 – Hexagonal – D 5.62 (432)

Lead fluoride – PbF_2(I) – 245.21 – Colorless – Cubic – D 7.678^{24} (913) – M.P. 824 (521) – B.P. 1293 (519)

Lead fluoride – PbF_2(II) – 245.21 – Colorless – Rhombic – D 8.37^{24} (913) – Transition to I 220-280 (913)

Lead (IV) fluoride – PbF_4 – 283.21 – Colorless – Tetragonal – D 6.7 (1048) – M.P. ~600 (1048)

Lead formate – $Pb(HCO_2)_2$ – 297.25 – Colorless – Rhombic – D 4.63 (469) – D.T. 190 (469) – R.I. p 1.789, m 1.852, g 1.877 (469)

Lead iron (III) silicate – $3PbO \cdot 2Fe_2O_3 \cdot 3SiO_2$ (Nat. Melanotekite) – 1169.17 – Black – Rhombic – D 5.73 (469) – R.I. p 2.12, m 2.17, g 2.31 (469)

Lead manganese (III) silicate – $3PbO \cdot 2Mn_2O_3 \cdot 3SiO_2$ (Nat. Kentrolite) – 1165.53 – Dark reddish brown – Rhombic – D 6.19 (617) – R.I. p 2.10, m 2.20, g 2.310 (617)

Lead molybdate – $PbO \cdot MoO_3$ (Nat. Wulfenite) – 367.16 – Yellowish white – Tetragonal – D 6.7 (469) – M.P. 1065 (521) – R.I. o 2.402, e 2.304 (All for Li-line) (469)

Lead molybdate – $2PbO \cdot MoO_3$ – 590.37 – M.P. 951 (469)

Lead nitrate – $Pb(NO_3)_2$ – 331.23 – Colorless – Cubic – D 4.535^{25} (1088) – D.T. 360 (760 mm.) (728) – R.I. 1.7807 (1088)

Lead oxalate – PbC_2O_4 – 295.23 – Colorless – D 5.28 (469)

Lead oxide, sub- – Pb_2O – 430.42 – Gray – D 8.35^{18} (766)

Lead oxide – PbO (Massicotite) – 223.21 – Yellow – Rhombic – D 8.0 (469) – R.I. p 2.51, m 2.61, g 2.71 (All Li line) (469)

Lead oxide – PbO(I) (Metastable) (Litharge) – 223.21 – Yellow – Rhombic – D 9.632^{20} (195) – M.P. 885 (328) (195) – B.P. 1472 (519)

Lead oxide – PbO(II) (Stable) (Litharge) – 223.21 – Red – Tetragonal – D 9.349^{20} (195) – Transition to I 489 (195) (785) – R.I. o 2.665, e 2.535 (All Li line) (469)

Lead (II, IV) oxide – Pb_2O_3 – 462.42 – Black – Triclinic – D 9.925 (187)

Lead (II, IV) oxide – Pb_3O_4 (Minium) – 685.63 – Vivid red, streak orange yellow – Tetragonal – D 9.1 (469) – R.I. mean 2.42 (Li line) (617)

Lead (IV) oxide – PbO_2 (Plattnerite) – 239.21 – Reddish brown – Tetragonal – D 9.604 (936) – D.T. 312 (760 mm.) (598) – R.I. o 2.3, e – (469)

Lead oxide – Pb_5O_8 – 1164.05 – Black – Tetragonal – D 9.514 (187) – Transition to Pb_3O_4 at 390 (186)

Lead oxide, hydrate – $5PbO \cdot 2H_2O$ – 1152.08 – Colorless – Monoclinic – D 7.73 (188)

Lead phosphate, meta- – $PbO \cdot P_2O_5$ – 365.25 – Colorless – M.P. 800 (469)

Lead phosphate, pyro- – $2PbO \cdot P_2O_5$ – 588.46 – Colorless – Rhombic – D 5.8 (469) – M.P. 824 (469)

Lead phosphate, ortho- – $3PbO \cdot P_2O_5$ – 811.67 – Colorless – Tetragonal – D 7.011 (1116) – M.P. 1014 (469) – T.P. 782 (469) – R.I. o 1.970, e 1.936 (469)

Lead phosphate – $4PbO \cdot P_2O_5$ – 1034.88 – M.P. 982 (469)

Lead phosphate – $5PbO \cdot 2P_2O_5$ – 1400.13 – M.P. 946 (469)

Lead phosphate – $8PbO \cdot P_2O_5$ – 1927.72 – M.P. 860 (469)

Lead (IV) phosphate – $PbO_2 \cdot P_2O_5$ – 381.25 – D 4.935 (X-ray) (787) – D.T. 400-500 (787)

Lead phosphate chloride – $3Pb_3(PO_4)_2 \cdot PbCl_2$ (Pyromorphite) – 2713.13 – Hexagonal – D 6.8 (469) – M.P. 1156 (469) – T.P. 670 (250) – R.I. p 2.042, m 2.050, g 2.050 (469)

Lead phosphate fluoride – $3Pb_3(PO_4)_2 \cdot PbF_2$ – 2680.22 – M.P. 1098 (13)

Lead selenate – $PbSeO_4$ – 350.17 – White – Rhombic – D 6.37 (469)

Lead selenide – PbSe (Clausthalite) – 286.17 – Black – Cubic – D 8.10 (469) – M.P. 1065 (469)

Lead silicate – $PbO \cdot SiO_2$ – 283.27 – Colorless – Monoclinic – D 6.264^{25} (89) – M.P. 764 (328) – R.I. p 1.947, m 1.961, g 1.968 (469)

Lead silicate – $PbO \cdot SiO_2$ (Glass) – 283.27 – Colorless to slight yellow – D 5.835^{25} (89) – R.I. 1.916 (703)

Lead silicate – $2PbO \cdot SiO_2$ – 506.48 – Colorless – Prism – M.P. 743 (328) – R.I. p 2.13, m 2.15, g 2.18 (328)

Lead silicate – $3PbO \cdot SiO_2$ – 729.69 – M.P. 710 (584)

Lead silicate – $3PbO \cdot 2SiO_2$ (Nat. Barysilite) – 789.75 – Colorless – Trigonal – D 6.72 (469) – M.P. 690 (434) – R.I. o 2.07, e 2.05 (469)

Lead silicate – $4PbO \cdot SiO_2$(I) – 952.90 – Plate – M.P 725 (Incong.) (328) – R.I. p 2.31, m 2.34, g 2.38 (328)

Lead silicate – $4PbO \cdot SiO_2$(II) – 952.90 – Transition to I 720 (328) – R.I. ∼ 2.34 (328)

Lead silicate – $4PbO \cdot SiO_2$(III) – 952.90 – Transition to II 140 (670) – R.I. ∼ 2.34 (328)

Lead silicate, boro- – $5PbO \cdot B_2O_3 \cdot SiO_2$ – 1245.75 – Rhombic – M.P. 551 (Incong.) (327) – R.I. o 2.085, e 2.04 (327)

Lead silicate, thio- – $3PbS \cdot 2SiS_2$ – 902.17 – Brick red – D 5.470^{25} (697) – M.P. 816 (697)

Lead sulfate – $PbSO_4$(I) – 303.27 – Monoclinic – M.P. 1087 (521)

Lead sulfate – $PbSO_4$(II) (Anglesite) – 303.27 – Colorless – Rhombic – D 6.07^{20} (611) – Transition to I 866 (397) – R.I. p 1.8771, m 1.8823, g 1.8937 (469)

Lead sulfate – $2PbO \cdot SO_3$ (Lanarkite) – 526.48 – Colorless – Monoclinic – D 6.92 (469) – M.P. 977 (469) – R.I. p 1.928, m 2.007, g 2.036 (837)

Lead sulfate – $3PbO \cdot SO_3$ – 749.69 – Colorless – M.P. 961 (479) – T.P. 450 (479)

Lead sulfide – PbS – 239.27 – Metallic – Cubic – D 7.590^{20} (303) – M.P. 1114 (521) – B.P. 1281 (519) – R.I. 3.912 (469)

Lead telluride – PbTe (Altaite) – 334.82 – Cubic – D 8.16 (469) – M.P. 917 (469)

Lead titanate – $PbO \cdot TiO_2$ – 303.11 – Yellow – Rhombic – D 7.52 (200) – R.I. 2.7 (847)

Lead tungstate – $PbO \cdot WO_3$(I) (Raspite) – 455.13 – Monoclinic – M.P. 1123 (469) – R.I. p 2.27, m 2.27, g 2.30 (469)

Lead tungstate – $PbO \cdot WO_3$(II) (Stolzite) – 455.13 – Tetragonal – D 8.23 (469) – Transition to I 877 (479) – R.I. o 2.2685, e 2.182 (469)

Lead tungstate – $2PbO \cdot WO_3$ – 678.34 – M.P. 899 (479)

Lithium – Li – 6.940 – White – Cubic – D 0.53^{20} (15) – M.P. 186 (14) (1026) – B.P. 1372 (15)

Lithium aluminate – $Li_2O \cdot Al_2O_3$ – 131.82 – Rhombic – D 2.554^{25} (469) – M.P. 1900-2000 (39) – R.I. p 1.604, m –, g 1.615 (487)

Lithium aluminate – $Li_2O \cdot 2Al_2O_3$ – 233.76 – A definite compound (455)

Lithium aluminate – $Li_2O \cdot 5Al_2O_3$ – 539.58 – Cubic – D 3.606^{20} (568) – M.P. > 1600 (Incong.) (568) – R.I. 1.735 (568)

Lithium aluminum fluoride – $3LiF \cdot AlF_3$ – 161.79 – M.P. 790 (272)

Lithium aluminum silicate – $Li_2O \cdot Al_2O_3 \cdot 2SiO_2$ (Encryptite) – 251.94 – Rhombic – D 2.362 (231) – M.P. 1388 (469) – R.I. p –, m 1.531, g 1.531 (482) (231)

Lithium aluminum silicate – $Li_2O \cdot Al_2O_3 \cdot 2SiO_2$ (Glass) – 251.94 – Colorless – D 2.429 (348) – R.I. 1.5410 (482)

Lithium aluminum silicate – $Li_2O \cdot Al_2O_3 \cdot 4SiO_2$(I) – 372.06 – Colorless – Monoclinic – M.P. 1400 (469) – R.I. p –, m 1.740 (Mean), g – (633)

Lithium aluminum silicate – $Li_2O \cdot Al_2O_3 \cdot 4SiO_2$(II) – 372.06 – Colorless – Trigonal – D 2.280 (231) – Transition to I 956 (674) – R.I. o 1.524, e – (231)

Lithium aluminum silicate – $Li_2O \cdot Al_2O_3 \cdot 4SiO_2$ (Glass) – 372.06 – Colorless – D $2.388^{25.2}$ (487) – R.I. 1.524 (482)

Lithium aluminum silicate – $Li_2O \cdot Al_2O_3 \cdot 5SiO_2$ – 432.12 – Tetragonal – D 2.40^{12} (469)

Lithium aluminum silicate – $Li_2O \cdot Al_2O_3 \cdot 6SiO_2$ – 492.18 – D 2.41^{11} (469) – M.P. 1180 (39) – R.I. Mean 1.502 (39)

Lithium aluminum silicate – $Li_2O \cdot Al_2O_3 \cdot 8SiO_2$ (Nat. Petalite) – 612.30 – Monoclinic – D 2.4 (469) – M.P. 1370 – T.P. 1100-1200 (39) (469) – R.I. p 1.504, m 1.510, g 1.516 (469)

Lithium aluminum silicate – $Li_2O \cdot Al_2O_3 \cdot 8SiO_2$ (Glass) – 612.30 – Colorless – R.I. 1.4946 (1075)

Lithium aluminum silicate – $Li_2O \cdot 3Al_2O_3 \cdot 4SiO_2$ (Nat. Cookeite) – 575.94 – Monoclinic – D 2.68 (617) – R.I. p 1.576, m 1.579, g 1.579 (608)

Lithium aluminum silicate – $2Li_2O \cdot Al_2O_3 \cdot 5SiO_2$ – 462.00 – Fan-like crystals – D 2.388 (39) – M.P. 965 (39)

Lithium aluminum silicate – $3Li_2O \cdot Al_2O_3 \cdot 3SiO_2$ – 371.76 – D 2.517 (39) – M.P. 1080 (Incong.) (39)

Lithium arsenate – $3Li_2O \cdot As_2O_5$ – D 3.07 (469)

Lithium beryllium fluoride – $2LiF \cdot BeF_2$ – 98.90 – D 2.167^{30} (826) – M.P. $\sim$ 470 (351) – R.I. Mean $\sim$ 1.3 (351)

Lithium beryllium fluoride, hydrate – $2LiF \cdot BeF_2 \cdot H_2O$ – 116.92 – D 1.944^{30} (826)

Lithium borate – $Li_2O \cdot B_2O_3$ – 99.52 – Colorless – M.P. 845 (521) – T.P. 785 (538)

Lithium borate – $Li_2O \cdot 2B_2O_3$ – 169.16 – M.P. 900 (469)

Lithium borate, hydrate – $Li_2O \cdot B_2O_3 \cdot 16H_2O$ – 387.78 – Colorless – Trigonal – D $1.38^{14.7}$ (469) – M.P. 47 (469)

Lithium borate fluoride – $3LiBO_2 \cdot 2LiF$ – 201.16 – M.P. 755 (538) – T.P. 545, 585 (538)

Lithium calcium silicate – $Li_2O \cdot CaO \cdot SiO_2$ – 146.02 – Colorless – D 2.847 (918)

Lithium calcium silicate – $4Li_2O \cdot 6CaO \cdot 5SiO_2$ – 756.30 – Colorless – D 2.566 (918) – M.P. 1104 (918)

Lithium calcium silicate – $6Li_2O \cdot 4CaO \cdot 5SiO_2$ – 703.90 – Colorless – D 2.591 (918) – M.P. 1092 (918)

Lithium carbonate – Li_2CO_3 – 73.89 – Colorless – Monoclinic – D 2.111 (469) – M.P. 735 (520) – D.T. 1310 (760 mm.) (520) – R.I. p 1.428, m 1.567, g 1.572 (469)

Lithium chlorate – $LiClO_3$ – 90.40 – Colorless – Rhombic – M.P. 127.6 (587) – T.P. 41.5, 99 (587) – D.T. 270 (469)

Lithium chloride – LiCl – 42.40 – Cubic – D 2.068^{25} (469) – M.P. 614 (521) – B.P. 1382 (519) – R.I. 1.662 (954)

Lithium ferrite – $Li_2O \cdot Fe_2O_3$(I) – 189.56 – Cubic – D 4.368 (801) – R.I. 2.40 (801)

Lithium ferrite – $Li_2O \cdot 5Fe_2O_3$ – 828.28 – Cubic – D 4.77 (X-ray) (450) (972)

Lithium fluoride – LiF – 25.94 – Colorless – Cubic – D 2.63905^{25} (465) – M.P. 847 (521) – T.P. 762, 812 (538) – B.P. 1681 (519) – R.I. 1.392057^{21} (647)

Lithium formate – $LiHCO_2$ – 51.95 – Colorless – Monoclinic – D 1.53 (X-ray) (56) – M.P. 280 (931)

Lithium germanate – $Li_2O \cdot GeO_2$ – 134.48 – Monoclinic – D 3.53^{21} (917) – M.P. 1239 (917) – R.I. p –, m 1.73, g – (917)

Lithium germanate – $2Li_2O \cdot GeO_2$ – 164.36 – M.P. 1298 (917)

Lithium hydroxide – LiOH – 23.95 – Colorless – Tetragonal – D 1.46 (261) – M.P. 462 (521) – D.T. 924 (760 mm.) (501) – R.I. o 1.464, e 1.452 (261)

Lithium hydroxide, hydrate – $LiOH \cdot H_2O$ – 41.96 – Monoclinic – D 1.51 (784)

Lithium iron (III) fluoride – $3LiF \cdot FeF_3$ – 190.67 – Colorless – Cubic – D 2.05 (X-ray) (694) – R.I. 1.42 (732)

Lithium iron (II) phosphate – $Li_2O \cdot 2FeO \cdot P_2O_5$ (Nat. Triphylite) – 315.62 – Rhombic – D 3.55 (469) – R.I. p –, m 1.702, g – (469)

Lithium lanthanum silicate – $Li_2O \cdot La_2O_3 \cdot 2SiO_2$ – 475.84 – Colorless – Hexagonal – R.I. o 1.870, e 1.843 (256)

Lithium manganate, per- – $LiMnO_4$ – 125.87 – D 2.06^{25} (208) – Decomposition begins 190 (208)

Lithium manganese (II) phosphate – $Li_2O \cdot 2MnO \cdot P_2O_5$ (Nat. Lithiophilite) – 313.78 – Rhombic – D 3.5 (469) – R.I. p 1.676, m 1.679, g 1.687 (469)

Lithium molybdate – $Li_2O \cdot MoO_3$ – 173.83 – Colorless – Trigonal, Hexagonal – D 2.66 (X-ray) (348) (972) – M.P. 705 (521)

Lithium nitrate – $LiNO_3$ – 68.95 – Colorless – Trigonal – D 2.366^{20} (388) – M.P. 251.4 (634) – R.I. o 1.735, e 1.435 (469)

Lithium nitrate, hydrate – $LiNO_3 \cdot 3H_2O$ – 123.00 – Prism or Needle – M.P. 29.88 (469)

Lithium nitrite – $LiNO_2$ – 52.95 – Colorless – D 1.793 (157) – M.P. 225 (157) – D.T. 200 (157)

Lithium oxalate – $Li_2C_2O_4$ – 101.90 – Rhombic – D $2.121^{17.5}$ (469) – R.I. p 1.465, m 1.53, g 1.696 (411)

Lithium oxide – Li_2O – 29.88 – Cubic – D $2.013^{25.2}$ (469) – M.P. 1700 (469) – B.P. 1200 (600 mm.) (636) – R.I. 1.644 (481)

Lithium oxide, per- – Li_2O_2 – 45.88 – D.T. 195 (175)

Lithium phosphate, meta- – $Li_2O \cdot P_2O_5$ – 171.92 – Plate – D 2.461 (469)

Lithium phosphate, ortho- – $3Li_2O \cdot P_2O_5$ – 231.68 – Rhombic – D $2.537^{17.5}$ (469) – M.P. 837 (469)

Lithium phosphate, hydrate – $Li_2O \cdot P_2O_5 \cdot 2H_2O$ – 207.95 – D 2.461 (469) – M.P. > 100 (469)

Lithium phosphate, hydrate – $3Li_2O \cdot P_2O_5 \cdot 24H_2O$ – 664.06 – Trigonal – D 1.645 (469) – M.P. 100 (469)

Lithium selenide – Li_2Se – 92.84 – Reddish brown – D 2.91 (1124)

Lithium silicate – $Li_2O \cdot SiO_2$ – 89.94 – Colorless – Rhombic – D 2.478^{25} (89) – M.P. 1201 (469) – R.I. o 1.591, e 1.611 (574)

Lithium silicate – $Li_2O \cdot SiO_2$ (Glass) – 89.94 – Colorless – R.I. 1.557 (Quenched sample) (576)

Lithium silicate – $Li_2O \cdot 2SiO_2$ – 170.00 – Colorless – Rhombic or Monoclinic – D 2.454^{25} (469) – M.P. 1033 (Incong.) (577) – T.P. 936 (577) – R.I. p 1.547, m 1.550, g 1.558 (574)

Lithium silicate – $Li_2O \cdot 2SiO_2$ (Glass) – 170.00 – Colorless – R.I. 1.535 (703)

Lithium silicate – $2Li_2O \cdot SiO_2$ – 119.82 – Colorless – Rhombic – D 2.326^{25} (89) – M.P. 1249 (Incong.) (521) – R.I. p 1.602, m –, g 1.610 (574)

Lithium silicate, fluo- – $2LiF \cdot SiF_4$ – 155.94 – D 2.88 (348)

Lithium silicate, fluo-, hydrate – $2LiF \cdot SF_4 \cdot 2H_2O$ – 191.97 – Monoclinic – D 2.3 (469)

Lithium sulfate – Li_2SO_4(I) – 109.94 – Colorless – Cubic – M.P. 857 (521)

Lithium sulfate – Li_2SO_4(II) – 109.94 – Colorless – Hexagonal or Rhombic

Lithium sulfate – Li_2SO_4(III) – 109.94 – Colorless – Monoclinic – D 2.221 (469) – T.P. 566, 569 (397) – R.I. p –, m 1.465, g – (469)

Lithium sulfate, bi- – $LiHSO_4$ – 104.01 – Colorless – D 2.123^{18} (469)

Lithium sulfate, hydrate – $Li_2SO_4 \cdot H_2O$ – 127.96 – Colorless – Monoclinic – D 2.06 (469) – R.I. p 1.460, m 1.477, g 1.488 (469)

Lithium sulfide – Li_2S – 45.94 – Colorless or light chocolate – Cubic – D 1.66 (469) – M.P. 900-975 (780)

Lithium sulfide, per- – Li_2S_2 – 78.00 – Brownish yellow – M.P. 369.5 (780)

Lithium telluride – Li_2Te – 141.49 – Colorless – Cubic – D 3.24 (1124)

Lithium titanate – $Li_2O \cdot TiO_2$ – 109.78 – Colorless – Cubic – D 3.418^{20} (568) – R.I. 2.087 (568)

Lithium titanium fluoride – $2LiF \cdot TiF_4$ – 173.78 – M.P. 480 (339)

Lithium tungstate – $Li_2O \cdot WO_3$ – 261.80 – Colorless – Hexagonal, Trigonal – D 3.71 (X-ray) (348) (972) – M.P. 742 (521)

Lithium tungstate – $Li_2O \cdot 2WO_3$ – 493.72 – Rhombic – M.P. 745 (643) – T.P. 687 (643)

Lithium tungstate – $Li_2O \cdot 4WO_3$ – 957.56 – Slight yellow – M.P. 800 (447)

Lithium zirconium silicate – $4Li_2O \cdot 3ZrO_2 \cdot 5SiO_2$ – 789.48 – Slightly yellow – D 4.024 (918) – M.P. 1152 (918)

Lutecium – Lu – 174.99

Lutecium chloride – $LuCl_3$ – 281.36 – D 3.98 (469) – M.P. 892 (493)

Lutecium oxide – Lu_2O_3 – 397.98 – Cubic – D 9.42 (X-ray) (1106)

Lutecium sulfate, hydrate – $Lu_2(SO_4)_3 \cdot 8H_2O$ – 782.29 – D 3.333^{20} (423)

Magnesium – Mg – 24.32 – White – Hexagonal – D 1.74^{20} (15) – M.P. 659 (1068) – B.P. 1107 (15)

Magnesium aluminate – $MgO \cdot Al_2O_3$ (Spinel) – 142.26 – White – Cubic – D 3.578 (840) – M.P. 21_{15} (1052) – R.I. 1.7189 (840)

Magnesium aluminate – $MgO \cdot Al_2O_3$ (Glass) – 142.26 – Colorless – R.I. 1.675 (319)

Magnesium aluminate – $MgO \cdot 2Al_2O_3$ – 244.20 – White – R.I. 1.7251 (840)

Magnesium aluminate – $MgO \cdot 3Al_2O_3$ – 346.14 – White – Cubic – D 3.62^{14} (133) – R.I. 1.7264 (840)

Magnesium aluminate – $MgO \cdot 4Al_2O_3$ – 448.08 – White – D 3.625 (840) – R.I. 1.7284 (840)

Magnesium aluminate – $MgO \cdot 5Al_2O_3$ – 550.02 – White – R.I. 1.7309 (840)

Magnesium aluminum silicate – $MgO \cdot Al_2O_3 \cdot SiO_2$ – 202.32 – Colorless – Rhombic – M.P. < 1400 (Incong.) (233) – R.I. p –, m –, g 1.649 (233)

Magnesium aluminum silicate – $2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$(I) (Cordierite) – 584.82 – Colorless – Rhombic – M.P. 1500 (823) – R.I. Mean 1.527 (823)

Magnesium aluminum silicate – $2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$(II) (Cordierite) – 584.82 – Colorless – Monoclinic – Transition to I > 950 (823)

Magnesium aluminum silicate – $3MgO \cdot Al_2O_3 \cdot 3SiO_2$ (Nat. Pyrope) – 403.08 – Colorless – Cubic – D 3.5 (469) – M.P. 1270 (1118) – R.I. 1.705 (Mineral, 1.74-1.76) (469)

Magnesium aluminum silicate – $5MgO \cdot 6Al_2O_3 \cdot 2SiO_2$ (Nat. Sapphirin) – 933.36 – Monoclinic – D 3.45 (469) – R.I. p 1.705, m 1.709, g 1.711 (469)

Magnesium aluminum silicate, hydrate – $4MgO \cdot Al_2O_3 \cdot 2SiO_2 \cdot 5H_2O$ (Nat. Colerainite) – 473.42 – Hexagonal – D2.51 (469) – R.I. o 1.56, e – (469)

Magnesium aluminum silicate, hydrate – $5MgO \cdot Al_2O_3 \cdot 3SiO_2 \cdot 4H_2O$ (Nat. Leuchtenbergite) – 555.78 – Monoclinic – D 2.7 (469) – R.I. p 1.585, m 1.586, g 1.596 (469)

Magnesium aluminum silicate, hydrate – $5MgO \cdot Al_2O_3 \cdot 6SiO_2 \cdot 4H_2O$ (Nat. Zebedassite) – 735.96 – Rhombic – D 2.19 (469) – R.I. p –, m 1.52, g – (469)

Magnesium arsenate, meta- – $MgO \cdot As_2O_5$ – 270.14 – D.T. 500 (379)

Magnesium arsenate, pyro- – $2MgO \cdot As_2O_5$ – 310.46 – D 3.75 (189) – D.T. 900 (379)

Magnesium arsenate, ortho- – $3MgO \cdot As_2O_5$ – 350.78 – D.T. 1000 (379)

Magnesium borate – $MgO \cdot B_2O_3$ – 109.96 – Colorless – D 2.6 (348) – M.P. 1191 (1011) – R.I. p 1.617, m –, g 1.661 (1011)

Magnesium borate – $MgO \cdot B_2O_3$ (Glass) – 109.96 – Colorless – D 2.520 (348)

Magnesium borate – $2MgO \cdot B_2O_3$ – 150.28 – Colorless – M.P. 1381 (1011) – R.I. p 1.588, m 1.659, g 1.673 (1011)

Magnesium borate – $3MgO \cdot B_2O_3$ (Kotoite) – 190.60 – Colorless – Rhombic – D 2.99 (469) – M.P. 1400 (1011) – R.I. p 1.653, m 1.654, g 1.675 (469)

Magnesium borate, hydrate – $MgO \cdot B_2O_3 \cdot 3H_2O$ (Nat. Pinnoite) – 164.01 – Colorless – Tetragonal – D 2.30 (469) – R.I. o 1.565, e 1.575 (469)

Magnesium borate, hydrate – $MgO \cdot 2B_2O_3 \cdot 9H_2O$ – 341.74 – Colorless – Hexagonal – D 1.70 (177) – R.I. p 1.442, m –, g 1.485 (736)

Magnesium borate, hydrate – $MgO \cdot 3B_2O_3 \cdot 7.5H_2O$ – 394.36 – Colorless – D 1.86 (177) – R.I. p 1.463, m –, g 1.508 (736)

Magnesium borate, hydrate – $MgO \cdot 4B_2O_3 \cdot 4H_2O$ (Nat. Paternoite) – 380.94 – Colorless – R.I. p 1.509, m 1.528, g 1.548 (45)

Magnesium borate, hydrate – $2MgO \cdot B_2O_3 \cdot H_2O$ (Nat. Camsellite or *Ascharite) – 168.30 – Colorless – Rhombic – D 2.7 (469) – R.I. p 1.575, m 1.620, g 1.649 (469)

Magnesium borate, hydrate – $2MgO \cdot 3B_2O_3 \cdot 13H_2O$ (Nat. Kurnakovite) – 523.77 – Colorless – Monoclinic – D 1.85 (350) – D.T. 81-105 (350) – R.I. p 1.489, m 1.510, g 1.525 (350)

Magnesium borate, hydrate – $2MgO \cdot 3B_2O_3 \cdot 15H_2O$ (Inderite) – 559.80 – Colorless – Rhombic – D 1.78 (77) – R.I. p –, m 1.488, g 1.504 (349)

Magnesium borate, hydrate – $10MgO \cdot 4B_2O_3 \cdot 3H_2O$ (Nat. Szaibelyite) – 735.81 – D 3 (469) – R.I. o 1.65, e 1.59 (469)

Magnesium borate, fluo- – $MgF_2 \cdot 2BF_3$ – 197.96 – Trigonal – R.I. p –, m < 1.36, g – (469)

Magnesium carbonate – $MgCO_3$ (Magnesite) – 84.33 – Colorless – Trigonal – D 3.037 (469) – D.T. 408 (760 mm.) (520) – R.I. o 1.700, e 1.509 (469)

Magnesium carbonate, hydrate – $MgCO_3 \cdot 3H_2O$ (Nat. Nesquehonite) – 138.38 – Colorless – Rhombic – D 1.850 (469) – D.T. 320 (in CO_2) (677) R.I. p 1.495, m 1.501, g 1.526 (469)

Magnesium carbonate, hydrate – $MgCO_3 \cdot 5H_2O$ (Nat. Lansfordite) – 174.41 – Monoclinic – D 1.73 (469) – R.I. p 1.456, m 1.468, g 1.507 (469)

Magnesium chloride – $MgCl_2$ – 95.23 – Colorless – Hexagonal – D 2.325 (469) – M.P. 712 (469) – B.P. 1418 (519) – R.I. o 1.675, e 1.59 (469)

Magnesium chromate – $MgO \cdot CrO_3$ – 140.33 – Orange – D.T. 536 (760 mm.) (887)

Magnesium chromite – $MgO \cdot Cr_2O_3$ – 192.34 – Green – Cubic – D 4.394 (462) – M.P. 2000 (51) – R.I. 2.08 (230)

Magnesium cobalt (III) oxide – $MgO \cdot Co_2O_3$ – 206.20 – Cubic – D 4.96 (X-ray) (454)

Magnesium cobalt (IV) oxide – $MgO \cdot CoO_2$ – 131.26 – D 5.06 (469)

Magnesium columbate – $4MgO \cdot Cb_2O_5$ – 427.10 – Colorless or pale yellow – Hexagonal – D 4.4 (469)

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* See Agafonova and Iskyul (3)

Magnesium ferrite – $MgO \cdot Fe_2O_3$ – 200.00 – Purple brown to black – Cubic – D 4.481 (798) – M.P. 1750 (846) – R.I. 2.39 (804)

Magnesium fluoride – MgF_2 – 62.32 – Colorless – D 3.127^{25} (557) – M.P. 1260 (831) – B.P. 2260 (876) – R.I. o 1.378, e 1.390 (469)

Magnesium formate – $Mg(HCO_2)_2$ – 114.36 – Colorless – Monoclinic – D 1.75 (26)

Magnesium gallate – $MgO \cdot Ga_2O_3$ – 227.76 – D 5.298 (X-ray) (402)

Magnesium germanate – $2MgO \cdot GeO_2$ – 185.24 – White – T.P. 1065 (489)

Magnesium hydroxide – $Mg(OH)_2$ (Brucite) – 58.34 – Colorless – Trigonal – D 2.4 (469) – D.T. 415 (623) – R.I. o 1.559, e 1.580 (469)

Magnesium lanthanate – $MgO \cdot La_2O_3$ – 366.16 – M.P. 2030 (1049)

Magnesium nitrate, hydrate – $Mg(NO_3)_2 \cdot H_2O$ (Nitromagnesite) – 166.35 – Colorless – R.I. p 1.344, m 1.506, g 1.506 (469)

Magnesium nitrate, hydrate – $Mg(NO_3)_2 \cdot 2H_2O$ – 184.37 – Colorless – Short prisms – D 2.026^{25} (118) – M.P. 130.9 (265)

Magnesium nitrate, hydrate – $Mg(NO_3)_2 \cdot 6H_2O$ – 256.43 – Colorless – Monoclinic – D 1.636^{25} (118) – M.P. 89.9 (265)

Magnesium nitrate, hydrate – $Mg(NO_3)_2 \cdot 9H_2O$ – 310.48 – Colorless – Transition to $Mg(NO_3)_2 \cdot 6H_2O$ at — 14.7 (265)

Magnesium oxide – MgO (Periclase) – 40.32 – Colorless, transparent – Cubic – D 3.5761^{25} (243) – M.P. 2800 (469) – B.P. 2825 (885) – R.I. 1.73789 (967)

Magnesium phosphate, meta- – $MgO \cdot P_2O_3$ (Nat. Pinnoite) – 182.36 – Colorless – Tetragonal – R.I. o 1.565, e 1.575 (102)

Magnesium phosphate, pyro- – $2MgO \cdot P_2O_5$ – 222.68 – Colorless – Monoclinic – D 3.058^{25} (22) – M.P. 1383 (22) – R.I. p 1.602, m 1.604, g 1.615 (469)

Magnesium phosphate, pyro- – $2MgO \cdot P_2O_5$ (Amorphous) – 222.68 – Colorless – D 2.598^{22} (469) (22)

Magnesium phosphate, ortho- – $3MgO \cdot P_2O_5$ – 263.00 – Colorless – Rhombic – M.P. 1184 (1079)

Magnesium phosphate, hydrate – $2MgO \cdot P_2O_5 \cdot 3H_2O$ – 276.73 – Colorless – D 2.326^{15} (905)

Magnesium phosphate, hydrate – $2MgO \cdot P_2O_5 \cdot 7H_2O$ (Nat. Newberyite) – 348.79 – Colorless – Rhombic – D 2.10 (469) – —$4H_2O$ at 207 (964) – R.I. p 1.514, m 1.518, g 1.533 (469)

Magnesium phosphate, hydrate – $2MgO \cdot P_2O_5 \cdot 15H_2O$ (Nat. Phosphor-roesslerite) – 492.92 – Colorless – Monoclinic – D 1.725 (309) – Dehyd. 176 (362) – R.I. p 1.477, m 1.485, g 1.486 (309)

Magnesium phosphate, hydrate – $3MgO \cdot P_2O_5 . \cdot 8H_2O$ (Nat. Bobierrite) – 407.13 – Colorless – Monoclinic – D 2.41 (469) – —$5H_2O$ at 120, —$7H_2O$ at 300, —$8H_2O$ at 400 (543) – R.I. p 1.510, m 1.520, g 1.543 (469)

Magnesium phosphate fluoride – Mg_2PO_4F (Nat. Wagnerite) – 162.62 – Monoclinic – D 3.12 (469) – T.P. 845 (1079) – R.I. p 1.569, m 1.570, g 1.582 (469)

Magnesium selenate, hydrate – $MgSeO_4 \cdot 6H_2O$ – 275.38 – Colorless – Monoclinic – D 1.928 (469) – R.I. p 1.4856, m 1.4892, g 1.4911 (469)

Magnesium selenide – MgSe – 103.28 – Red brown – Cubic – D 4.23 (416) – R.I. $>$ 2.42 (384)

Magnesium silicate – $MgO \cdot SiO_2$ (Clinoenstatite) – 100.38 – Colorless – Monoclinic – D 3.193 (8) – M.P. 1562 (Incong.) (949) – R.I. p 1.651, m 1.654, g 1.660 (469)

Magnesium silicate – $MgO \cdot SiO_2$ (Enstatite) – 100.38 – Colorless – Rhombic – D 3.175 (9) – Transition to Clinoenstatite at 1300, 1375 (220) – R.I. p 1.64, m –, g 1.65 (812)

Magnesium silicate – $MgO \cdot SiO_2$ (Protoenstatite) – 100.38 – Colorless – Transition to Enstatite at 970 (992)

Magnesium silicate – $MgO \cdot SiO_2$ (M-Amphibole) – 100.38 – Colorless – Monoclinic – D 2.872 (89) – Transition to Clinoenstatite 1150 (220)

Magnesium silicate – $MgO \cdot SiO_2$ (R-Amphibole) – 100.38 – Colorless – Rhombic – D 2.857 (221) – Transition to M-Amphibole 375-475, transition to Clinoenstatite 1150 (220)

Magnesium silicate – $MgO \cdot SiO_2$ (Glass) – 100.38 – Colorless – D 2.757 (703) – R.I. 1.5801 (615)

Magnesium silicate – $2MgO \cdot SiO_2$ (Forsterite) – 140.70 – Colorless – Rhombic – D 3.223 (32) – M.P. 1890 (1910 after temp. correction) (469) (949) – R.I. p 1.6359, m 1.6507, g 1.6688 (128)

Magnesium silicate, hydrate – $2MgO \cdot 3SiO_2 \cdot 4H_2O$ (Nat. Parasepiolite) – 332.88 – Rhombic – R.I. p –, m 1.506, g – (469)

Magnesium silicate, hydrate – $3MgO \cdot 2SiO_2 \cdot 2H_2O$ (Hornblendeasbest) – 277.11 – D 2.68 (651) – R.I. 1.595 (651)

Magnesium silicate, hydrate – $3MgO \cdot 2SiO_2 \cdot 2H_2O$ (Nat. Serpentine) – 277.11 – Rhombic – D 2.5 (469) – R.I. p –, m 1.54, g – (469)

Magnesium silicate, hydrate – $3MgO\cdot 3SiO_2\cdot 2H_2O$ – 277.11 – Rhombic – D 2.62 (469) – R.I. p 1.490, m 1.502, g 1.511 (469)

Magnesium silicate, hydrate – $4MgO\cdot 5SiO_2\cdot H_2O$ (Talc) (Not $3\ MgO\cdot 4SiO_2\cdot H_2O$ (264) – 479.60 – Colorless – Monoclinic – D 2.83 (264) – R.I. p 1.539, m 1.589, g 1.589 (469)

Magnesium silicate fluoride – $2MgO\cdot SiO_2\cdot MgF_2$ (Nat. Norbergite) – 203.02 – Rhombic – R.I. p 1.563, m 1.567, g 1.590 (616)

Magnesium silicate fluoride – $6MgO\cdot 8SiO_2\cdot MgF_2$ – 784.72 – R.I. p 1.583, m 1.590, g 1.598 (127)

Magnesium silicate, fluo-, hydrate – $MgSiF_6\cdot 6H_2O$ – 274.48 – Colorless – Trigonal – D 1.788 (385) – R.I. o 1.3439, e 1.3602 (469)

Magnesium sulfate – $MgSO_4$ – 120.38 – Colorless – Monoclinic – D 2.66 (469) – M.P. 1185 (469) – R.I. p 1.557, m –, g 1.582 (468)

Magnesium sulfate, hydrate – $MgSO_4\cdot H_2O$ (Nat. Kieserite) – 138.40 – Colorless – Monoclinic – D 2.57 (469) – R.I. p 1.523, m 1.535, g 1.586 (469)

Magnesium sulfate, hydrate – $MgSO_4\cdot 2H_2O$ – 156.41 – Colorless – D 2.3 (996) – R.I. p –, m 1.493, g – (850)

Magnesium sulfate, hydrate – $MgSO_4\cdot 4H_2O$ – 192.44 – Colorless – Monoclinic – R.I. p 1.490, m 1.491, g 1.497 (850)

Magnesium sulfate, hydrate – $MgSO_4\cdot 5H_2O$ – 210.46 – Colorless – Triclinic – D 1.718 (469) – R.I. p 1.482, m 1.492, g 1.493 (850)

Magnesium sulfate, hydrate – $MgSO_4\cdot 6H_2O$ – 228.48 – Colorless – Monoclinic – D 1.76 (469) – R.I. p 1.438, m 1.463, g 1.465 (850)

Magnesium sulfate, hydrate – $MgSO_4\cdot 7H_2O$ (Stable form) (Epsomite) – 246.49 – Colorless – Rhombic – D 1.68 (469) – $-6H_2O$ at 110, $-7H_2O$ at 350 (337) – R.I. p 1.4326, m 1.4554, g 1.4609 (469)

Magnesium sulfate, hydrate – $MgSO_4\cdot 7H_2O$ (Unstable form) – 246.49 – Colorless – Monoclinic – D 1.69 (834)

Magnesium sulfide – MgS – 56.38 – Yellowish gray – Cubic – D 2.8 (469) – > 2000 (1000) – R.I. 2.271 (386)

Magnesium telluride – MgTe – 151.93 – Cubic – D 3.86 (1105) – R.I. > 2.51 (~ 3.00) (384)

Magnesium tin (IV) oxide – $2MgO\cdot SnO_2$ – 231.34 – Cubic – D 4.738 (723)

Magnesium titanate – $MgO\cdot TiO_2$ (Nat. Geikielite) – 152.22 – Trigonal – D 3.98 (469) – R.I. o 2.31, e 1.95 (469)

Magnesium titanate – $MgO\cdot 2TiO_2$ – 264.12 – M.P. 1680 (1051)

Magnesium titanate – $2MgO\cdot TiO_2$ – 192.64 – Cubic – D 3.52 (404) – M.P. 1840 (1051)

Magnesium tungstate – $MgO\cdot WO_3$ – 272.24 – Yellowish white – Monoclinic – D 5.66 (137)

Magnesium zirconate – $MgO\cdot ZrO_2$ – 163.54 – M.P. 2150 (1050)

Manganese – Mn – 54.93 – Grayish white – Cubic – D 7.44^{20} (15) – M.P. 1254 (1068) – B.P. 2151 (15)

Manganese (II) aluminate – $MnO\cdot Al_2O_3$ (Manganspinel) – 172.87 – Amber – Cubic – D 4.12 (469) – M.P. 1560 (Incong.) (405) – R.I. $\sim$ 1.8 (1076)

Manganese (II) aluminum silicate – $MnO\cdot Al_2O_3\cdot 2SiO_2$ (Manganjustite) – 292.99 – M.P. 1130 (343)

Manganese (II) aluminum silicate – $2MnO\cdot Al_2O_3\cdot SiO_2$ (Mangangehlenite) – 303.86 – M.P. 1175 (343)

Manganese (II) aluminum silicate – $3MnO\cdot Al_2O_3\cdot 3SiO_2$ (Nat. Spessartite) – 494.91 – Cubic – D 4.180 (469) – M.P. 1200 (1118) – R.I. 1.800 (1076)

Manganese (II) arsenate – $3MnO\cdot As_2O_5$ (Nat. Armangite) – 442.61 – Trigonal – D 4.23 (469) – R.I. o 2.01, e 1.99 (617)

Manganese (II) borate – $3MnO\cdot 2B_2O_3$ – 352.07 – Triclinic – D 3.61 (469) – R.I. p 1.617, m 1.738, g 1.776 (469)

Manganese (II) borate , fluo- – $MnF_2\cdot 2BF_3$ – 228.57 – Trigonal – R.I. p –, m 1.359, g – (227)

Manganese (II) carbonate – $MnCO_3$ (Rhodochrosite) – 114.94 – Colorless or light brown – Trigonal – D 3.656 (71) – D.T. 369 (760 mm.) (469) – R.I. o 1.817, e 1.597 (469)

Manganese (II) chloride – $MnCl_2$ (Scacchite) – 125.84 – Reddish – Cubic – D 2.977^{25} (469) – M.P. 650 (469) – B.P. 1190 (469)

Manganese (II) chromite – $MnO\cdot Cr_2O_3$ – 222.95 – Gray – Cubic – D 4.87 (469)

Manganese (II) columbate – $MnO\cdot Cb_2O_5$ – 336.75 – Rose red – Rhombic – D 4.94^{18} (675)

Manganese (II) columbate – $3MnO\cdot 5Cb_2O_5$ – 1541.89 – Dirty yellow – D 4.97^{17} (675)

Manganese (II) ferrite – $MnO\cdot Fe_2O_3$ (Nat. Jacobsite) – 230.61 – Black – Cubic – D 4.75 (469) – M.P. 1570 (25) – R.I. 2.3 (617)

Manganese (II) fluoride – MnF_2 – 92.93 – Reddish – Tetragonal – D 3.891^{25} (91) – M.P. 856 (469)

Manganese (III) fluoride – MnF_3 – 111.93 – D 3.54 (469)

Manganese (II) formate – $Mn(HCO_2)_2$ – 144.97 – D 2.205 (469)

Manganese (II) nitrate, hydrate – $Mn(NO_3)_2 \cdot 3H_2O$ – 232.99 – Colorless – M.P. 34.8 (469)

Manganese (II) nitrate, hydrate – $Mn(NO_3)_2 \cdot 6H_2O$ – 287.04 – Colorless – Monoclinic – D 1.82 (469) – M.P. 25.8 (469)

Manganese (II) oxalate – MnC_2O_4 – 142.95 – D 2.43^{22} (469) – D.T. 300 (in vacuum) (43)

Manganese (II) oxide – MnO (Manganosite) – 70.93 – Green – Cubic – D 5.40^{18} (861) – M.P. 1785 (1072) – R.I. 2.16 (469)

Manganese (II, III) oxide – $MnO \cdot Mn_2O_3$ (Hausmannite) – 228.79 – Brownish red – Tetragonal – D 4.816^{25} (594) – M.P. 1590 (1049) – R.I. o 2.46, e 2.15 (469)

Manganese (III) oxide – Mn_2O_3(I) (Nat. Braunite) – 157.86 – Brownish black – Cubic – D 4.50 (469) – — 1/3O at 940 (in air) (688)

Manganese (III) oxide – Mn_2O_3(II) – 157.86 – D 4.802^{25} (594) – Transition to I 600 (240)

Manganese (IV) oxide – MnO_2 – 86.93 – D 4.943 (594) – — 1/2O 530 (688)

Manganese (IV) oxide – MnO_2 (Nat. Pyrolusite) – 86.93 – Black – Rhombic – D 5.03 (469)

Manganese (II) oxide, hydrate – $MnO \cdot H_2O$ (Nat. Pyrochroite) – 88.95 – Colorless – Trigonal – D 3.258^{18} (469) – R.I. o 1.723, e 1.681 (469)

Manganese (III) oxide, hydrate – $Mn_2O_3 \cdot H_2O$ (Nat. Manganite) – 175.88 – Black – Rhombic – D 4.3 (617) – R.I. p 2.24, m 2.24, g 2.53 (All Li line) (617)

Manganese (II) phosphate – $2MnO \cdot P_2O_5$ – 283.90 – Colorless – Monoclinic – D 3.707^{25} (469) – M.P. 1196 (22) – R.I. p 1.695, m 1.704, g 1.710 (22)

Manganese (II) phosphate, hydrate – $3MnO \cdot P_2O_5 \cdot 3H_2O$ (Nat. Reddingite) – 408.88 – Rhombic – D 3.1 (469) – R.I. p 1.651, m 1.656, g 1.683 (469)

Manganese (II) phosphate, hydrate – $5MnO \cdot 2P_2O_5 \cdot 4H_2O$ (Nat. Palaite) – 710.79 – Flesh colored – Monoclinic – D 3.17 (469) – R.I. p 1.652, m 1.656, g 1.660 (469)

Manganese (II) phosphate, hydrate – $5MnO \cdot 2P_2O_5 \cdot 5H_2O$ (Nat. Hureaulite) – 728.81 – Monoclinic – D 3.18 (469) – R.I. p 1.647, m 1.654, g 1.660 (469)

Manganese (II) selenate, hydrate – $MnO \cdot SeO_3 \cdot 2H_2O$ – 233.92 – Rhombic – D 2.949 (469)

Manganese (II) selenate, hydrate – $MnO \cdot SeO_3 \cdot 5H_2O$ – 287.97 – Pale red – Trigonal – D 2.334 (469)

Manganese (II) selenide – MnSe – 133.89 – Gray – Cubic – D 5.59^{15} (469)

Manganese (IV) selenide – $MnSe_2$ – 212.85 – Cubic – D 5.32 (X-ray) (258) (972)

Manganese (II) silicate – $MnO \cdot SiO_2$ (Rhodonite) – 130.99 – Pink – Triclinic – D 3.707^{25} (89) – M.P. 1274 (521) – R.I. p 1.733, m –, g 1.739 (1075)

Manganese (II) silicate – $MnO \cdot SiO_2$ (Glass) – 130.99 – D 3.48 (1075) – R.I. 1.700 (1075)

Manganese (II) silicate – $2MnO \cdot SiO_2$ (Tephroite) – 191.05 – Flesh red – Rhombic – D 4.05 (1007) – M.P. 1340 (Incong.) (1072) – R.I. p 1.7720, m 1.8038, g 1.8143 (365)

Manganese (II, III) silicate – $MnO \cdot 3Mn_2O_3 \cdot SiO_2$ – 604.57 – Tetragonal – D 4.78 (469)

Manganese (II) silicate, hydrate – $8MnO \cdot 7SiO_2 \cdot 5H_2O$ (Nat. Bementite) – 1077.94 – Rhombic – D 2.90 (469) – R.I. p 1.602, m 1.632, g 1.632 (469)

Manganese (II) silicate, fluo-, hydrate – $MnF_2 \cdot SiF_4 \cdot 6H_2O$ – 305.09 – Hexagonal – Pink – D 1.904^{18} (469) – R.I. o 1.357, e 1.374 (1075)

Manganese (II) sulfate – $MnSO_4$ – 150.99 – Colorless to reddish – D 3.181^{25} (696) – M.P. 700 (469)

Manganese (III) sulfate – $Mn_2(SO_4)_3$ – 398.04 – Brown, green – Hexagonal – D 3.24^{15} (53) – D.T. 320 (234)

Manganese (II) sulfate, hydrate – $MnSO_4 \cdot H_2O$ (Szmikite) – 169.01 – Pale pink – Monoclinic – D 2.874^{25} (696) – R.I. p 1.562, m 1.595, g 1.632 (469)

Manganese (II) sulfate, hydrate – $MnSO_4 \cdot 2H_2O$ – 187.02 – D 2.526 (469)

Manganese (II) sulfate, hydrate – $MnSO_4 \cdot 3H_2O$ – 205.04 – D 2.356 (469)

Manganese (II) sulfate, hydrate – $MnSO_4 \cdot 4H_2O$ – 223.05 – Pale red – Monoclinic – D 2.201^{25} (696) – R.I. p 1.508, m 1.518, g 1.522 (1075)

Manganese (II) sulfate, hydrate – $MnSO_4 \cdot 5H_2O$ – 241.07 – Pale pink – Triclinic – D 2.046^{25} (696) – M.P. 54 (675) – R.I. p 1.495, m 1.508, g 1.514 (1075)

Manganese (II) sulfide – MnS (Alabandite) – 86.99 – Red, green – Cubic – D 3.93^{22} (18) – M.P. 1530 (343) – R.I. 2.70 (Li line) (469)

Manganese (IV) sulfide – MnS_2 (Hauerite) – 119.05 – Reddish brown – Cubic – D 3.465 (96) – R.I. 2.69 (Li line) (469)

Manganese (II) tantalate – $MnO \cdot Ta_2O_5$ – 512.69 – Black – Rhombic – D 7.03 (469) – R.I. p 2.22, m 2.25, g 2.29 (469)

Manganese (IV) telluride – $MnTe_2$ – 310.15 – Dark green – Cubic – D 6.11 (X-ray) (258) (972)

Manganese (II) titanate – $MnO \cdot TiO_2$ (Pyrophanite) – 150.83 – Yellow – Trigonal – D 4.54 (469) – M.P. 1360 (Incong.) (369) – R.I. o 2.481, e 2.210 (469)

Manganese (II) titanate – $2MnO \cdot TiO_2$ – 221.76 – Cubic – D 4.49 (X-ray) (453) – M.P. 1455 (369)

Manganese (II) tungstate – $MnO \cdot WO_3$ (Nat. Huebnerite) – 302.85 – Brownish red – Monoclinic – D 7.2 (469) – R.I. p 2.17, m 2.22, g 2.32 (469)

Mercury – Hg – 200.61 – Silvery liquid – D 13.55^{20} (15) – M.P. —38.87 (14) (1026) – B.P. 356.57 (14)

Mercury (I) chloride – Hg_2Cl_2 (Calomel) – 472.14 – Colorless or yellowish – Tetragonal – D 7.15^{25} (469) – M.P. 525 (546) – B.P. 383.7 (469) – R.I. o 1.9733, e 2.6559 (469)

Mercury (II) chloride – $HgCl_2$ – 271.52 – Colorless – Rhombic – D 5.44^{25} (469) – M.P. 277 (469) – B.P. 304 (469) – R.I. p 1.725, m 1.8590, g 1.965 (469)

Mercury (I) fluoride – Hg_2F_2 – 439.22 – Pale yellow – Cubic – D 8.699^{25} (91) – M.P. 570 (469)

Mercury (II) fluoride – HgF_2 – 238.61 – Colorless – Cubic – D 9.073^{25} (91) – M.P. 645 (469) – B.P. 650 (469)

Mercury (I) oxide – Hg_2O – 417.22 – Brownish black – D 9.8 (469) – D.T. 100 (469)

Mercury (II) oxide – HgO – 216.61 – Red and yellow – Rhombic – D red 11.19, yellow 11.24 (637) – D.T. 100 (469) – R.I. p. 2.37, m 2.50, g 2.65 (All for Li line) (469)

Mercury (I) selenide – Hg_2Se – 480.18 – Violet – Cubic – D 8.877 (675)

Mercury (II) selenide – HgSe – 279.57 – Gray – Plates – D 8.266 (X-ray) (1103)

Mercury (I) selenite – $Hg_2O \cdot SeO_2$ – 528.18 – D.T. 180 (469)

Mercury (I) selenite – $3Hg_2O \cdot 4SeO_2$ – 1695.50 – D 7.350^{14} (675)

Mercury (I) sulfate – Hg_2SO_4 – 497.28 – Colorless – Monoclinic – D 7.56 (469)

Mercury (II) sulfate – $HgSO_4$ – 296.67 – Colorless – Rhombic – D 6.47 (469) – M.P. 850 (521)

Mercury (II) sulfide – HgS (I) (Metacinnabarite) – 232.67 – Black – Hexagonal – D 7.69 (842) – M.P. 1450 (120 atm.) (1001) – S.P. 580 (469) – R.I. o 2.58, e 2.82 (6710Å) (6)

Mercury (II) sulfide – HgS(II) (Cinnabar) – 232.67 – Red – Hexagonal – D 8.15 (842) – Transition to I 386 (523) (842) – R.I. o 2.85, e 3.20 (6710Å) (683)

Molybdenum – Mo – 95.95 – Silvery white – Cubic – D 10.2^{20} (15) – M.P. 2625 (14) (1026) – B.P. 4804 (15)

Molybdenum (III) chloride – $MoCl_3$ – 202.32 – Brownish red – Needle – D 3.578^{25} (78)

Molybdenum (V) chloride – $MoCl_5$ – 273.24 – Dark green – Iodine-like crystals – D 2.928^{25} (78) – M.P. 194 (469) – B.P. 268 (469)

Molybdenum (VI) fluoride – MoF_6 – 209.95 – Colorless – D 2.551^{18} (875) – M.P. 17 (469) – B.P. 36 (519)

Molybdenum (VI) fluoride oxide – MoF_4O – 187.95 – Colorless – D 3.001 (469) – M.P. 98 (469) – B.P. 180 (469)

Molybdenum (VI) fluoride oxide – MoF_2O_2 – 165.95 – Colorless – Radiated crystal – D 3.494 (469) – S.P. 270 (469)

Molybdenum (IV) oxide – MoO_2 – 127.95 – Brown – Tetragonal – D 6.4 (69) (348)

Molybdenum (VI) oxide – MoO_3 – 143.05 – Colorless with bluish shade – Rhombic – D 4.692^{21} (457) – M.P. 795 (469) – B.P. 1151 (519)

Molybdenum (VI) oxide, hydrate – $MoO_3 \cdot H_2O$ – 161.07 – Colorless – Hexagonal – D.T. 115 (469)

Molybdenum (VI) oxide, hydrate – $MoO_3 \cdot 2H_2O$ – 179.08 – Colorless – Monoclinic – D 3.124^{15} (469) – —$2H_2O$ at 200 (348)

Molybdenum (III) phosphate – $Mo_2O_3 \cdot 3P_2O_5$ – 666.02 – Yellow – D 3.28^{0} (469)

Molybdenum (III) sulfide – Mo_2S_3 – 288.08 – Steel gray – Needle – D 5.9 (469)

Molybdenum (IV) sulfide – MoS_2 (Molybdenite) – 160.07 – Bluish lead-gray – Hexagonal – D 4.80^{14} (469) – M.P. 1185 (469) – S.P. 450 (507) – R.I. 4.8 (6000Å) (1023)

Neodymium – Nd – 144.27 – Hexagonal – D 7.05^{20} (15) – M.P. 840 (14) (1026)

Neodymium chloride – $NdCl_3$ – 250.64 – Wine red – Prism – D 4.17 (540) – M.P. 761 (540) B.P. $>$ 1000 (1034)

Neodymium fluoride – NdF_3 – 201.27 – Pale lilac – Hexagonal – D 6.52 (X-ray) (751)

Neodymium germanate – $Nd_2O_3 \cdot GeO_2$ – 441.14 – Rhombic (342)

Neodymium molybdate – $Nd_2O_3 \cdot 3MoO_3$ – 768.39 – Violet – Tetragonal – D 5.14 (469) – M.P. 1176 (469) – R.I. o 2.0239, e 2.0218 (5700Å) (1109)

Neodymium nitrate, hydrate – $Nd(NO_3)_3 \cdot 6H_2O$ – 438.39 – Violet – Plates – M.P. 67.5 (Incong.) – T.P. 22 (312)

Neodymium oxide – Nd_2O_3 – 336.54 – Bluish violet – Trigonal, rhombic – D 7.24 (469)

Neodymium selenide – Nd_2Se_3 – 525.42 – Violet black – D 6.67 (551)

Neodymium silicate – $Nd_2O_3 \cdot SiO_2$ – 396.60 – Violet (960) – Hexagonal (341)

Neodymium silicate – $Nd_2O_3 \cdot 2SiO_2$ – 456.66 – Monoclinic (341) – M.P. Incong. (341)

Neodymium sulfate, hydrate – $Nd_2(SO_4)_3 \cdot 8H_2O$ – 820.85 – Rose red – Monoclinic – D 2.856^{20} (423) – R.I. p 1.5413, m 1.5505, g 1.5621 (469)

Neodymium sulfide – Nd_2S_3 – 384.72 – Greenish yellow – D 5.34^{25} (552) – M.P. 2200 (in vacuum) (793)

Nickel – Ni – 58.69 – White – Cubic – D 8.9^{20} (15) – M.P. 1455 (14) (1026) – B.P. 2900 (15)

Nickel (II) aluminate – $NiO \cdot Al_2O_3$ – 176.63 – Blue – Cubic – D 4.45 (230) – M.P. 2030 (1052) – R.I. 1.875 (230)

Nickel (II) arsenate – $3NiO \cdot As_2O_5$ (Nat. Xanthiosite) – 453.89 – Yellow – D 4.98 (469)

Nickel (II) borate, fluo- – $NiF_2 \cdot 2BF_3$ – 232.33 – Pseudorhombic – R.I. $p > 1.47$, m 1.48, $g < 1.50$ (227)

Nickel (II) carbonate – $NiCO_3$ – 118.70 – D.T. 325 (Max. rate) (956)

Nickel (II) chloride – $NiCl_2$ – 129.60 – Yellow – Pseudocubic – D 3.52 (74) – M.P. 1001 (280) – S.P. 987 (519)

Nickel (II) chromite – $NiO \cdot Cr_2O_3$ – 226.71 – Dark green – Cubic – D 5.16 (230) – R.I. 2.29 (Li line) (230)

Nickel (II) ferrite – $NiO \cdot Fe_2O_3$ – 234.37 – Reddish violet – Cubic – D 5.34 (230) – M.P. 1660 (25) – R.I. 2.69 (230)

Nickel (II) fluoride – NiF_2 – 96.69 – Yellowish green – Tetragonal – D 4.60^{25} (91)

Nickel (II) nitrate, hydrate – $Ni(NO_3)_2 \cdot 6H_2O$ – 290.89 – Emerald green – Monoclinic – D 2.05 (469) – —$2H_2O$ at 54.0 (934)

Nickel (II) oxalate – NiC_2O_4 – 146.71 – D 2.235 (469)

Nickel (II) oxide – NiO (Bunsenite) – 74.69 – Green – Cubic – D 6.8 (1075) – M.P. 1955 (1053) – R.I. 2.37 (Li-Line) (1075)

Nickel (III) oxide – Ni_2O_2 – 165.38 – Black – D 4.83 (469)

Nickel (II) oxide, hydrate – $NiO \cdot H_2O$ – 92.71 – Green – D 4.09 (X-ray) (722)

Nickel (II, III) oxide, hydrate – $Ni_3O_4 \cdot 2H_2O$ – 276.10 – D 3.412^{32} (469)

Nickel (II) selenate, hydrate – $NiO \cdot SeO_3 \cdot 6H_2O$ – 309.75 – Tetragonal – D 2.31 (469) – R.I. o 1.5393, e 1.5125 (469)

Nickel (II) selenide – NiSe – 137.65 – Gray or silver white – Hexagonal – D 8.46 (469)

Nickel (IV) selenide – $NiSe_2$ – 216.61 – Cubic – D 6.69 (X-ray) (509)

Nickel (II) silicate – $2NiO \cdot SiO_2$ – 209.44 – Light green – Rhombic – D 4.92 (X-ray) (986)

Nickel (II) silicate, hydrate – $3NiO \cdot 2SiO_2 \cdot 2H_2O$ (Nat. Bastite) – 380.22 – Monoclinic – R.I. p –, m 1.682, g – (24)

Nickel (IV) silicate, hydrate – $2NiO_2 \cdot 3SiO_2 \cdot 2H_2O$ (Nat. Connarite) – 365.59 – Yellowish green – Hexagonal – D 2.5 (617) – R.I. o 1.59, e 1.56 (617)

Nickel (II) silicate, fluo-, hydrate – $NiF_2 \cdot SiF_4 \cdot 6H_2O$ – 308.85 – Apple green – Trigonal – D 2.13 (469) – R.I. o 1.3910, e 1.4066 (469)

Nickel (II) sulfate– $NiSO_4$ – 154.75 – Yellowish green – Cubic – D 3.543^{25} (696) – D.T. 848 (760 mm.) (1080)

Nickel (II) sulfate, hydrate – $NiSO_4 \cdot H_2O$ – 172.78 – Green – D 2.885^{25} (696) – —H_2O at 250 (222)

Nickel (II) sulfate, hydrate – $NiSO_4 \cdot 6H_2O$(I) – 262.85 – Green – Monoclinic – Transition to $NiSO_4 \cdot H_2O$ at 200 (22)

Nickel (II) sulfate, hydrate – $NiSO_4 \cdot 6H_2O$(II) – 262.85 – Blue – Tetragonal – D 2.07 (469) – Transition to I 53.3 (59) – R.I. o 1.511, e 1.487 (469)

Nickel (II) sulfate, hydrate – $NiSO_4 \cdot 7H_2O$ (Morenosite) – 280.86 – Green – Rhombic and monoclinic – D 1.976 (696) – Transition to $NiSO_4 \cdot 6H_2O$(II) at 31.5 (59) – R.I. p 1.4693, m 1.4893, g 1.4923 (1075)

Nickel (I) sulfide – Ni_2S – 149.44 – Yellow – D 5.66 (675) – M.P. 645 (521)

Nickel (I, II) sulfide – Ni_3S_2 – 240.19 – M.P. 790 – T.P. 545 (308)

Nickel (II) sulfide – NiS (Millerite) – 90.75 – Yellow – Trigonal – D 5.25 (1074) – M.P. 797 (in N_2) (469) – T.P. 400 (93)

Nickel (II, III) sulfide – Ni_3S_4 – 304.31 – Cubic – D 4.7 (469)

Nickel (IV) sulfide – NiS_2 – 122.81 – Cubic – D 4.39 (93)

Nickel (II) titanate – $NiO \cdot TiO_2$ – 154.59 – Canary yellow – Rhombohedral – D 5.08 (986)

Nickel (II) tungstate – $NiO \cdot WO_3$ – 306.61 – Brown – Rhombic – D 6.88 (469)

Nitrogen – N (N_2) – 14.008 – Colorless gas – M.P. —210.0 (14) (1026) – B.P. —195.8 (15)

Nitrogen (III) fluoride – NF_3 – 71.01 – Colorless gas – M.P. —208.5 – T.P. —219 (884) – B.P. —129.0 (680)

Nitrogen (V) oxide – N_2O_5 – 108.02 – Colorless – Rhombic – D 2.05 (348) – M.P. 30 (469) – S.P. 32.5 (214)

Nitrogen (V) sulfide – N_2S_5 – 188.32 – Deep red – Iodine-like crystals – D 1.901^{18} (675) – M.P. 10-11 (675)

Osmium – Os – 190.2 – Bluish white – Hexagonal – D 22.5^{20} (15) – M.P. 2700 (14) (1026) – B.P. 5604 (15)

Osmium (VI) fluoride – OsF_6 – 304.20 – Green – M.P. 50-120 (348) – B.P. 203 (469)

Osmium (VIII) fluoride – OsF_8 – 342.20 – Yellow – Needle – D $2.74^{B.P.}$ (419) – M.P. 34.5 (469) – B.P. 47.5 (519)

Osmium (IV) oxide – OsO_2 – 222.20 – Brown – Cubic or hexagonal – D 11.38^{21} (590)

Osmium (VIII) oxide – OsO_4 – 254.20 – Yellow – Monoclinic – D 4.91 (469) – M.P. 56 (521) – B.P. 130 (519) – R.I. 1.56 (45°) (469)

Osmium (VIII) oxide – OsO_4 – 254.20 – Colorless – Monoclinic – D 4.95^{21} (590) – M.P. 42 (521) – B.P. 130 (519)

Osmium (IV) sulfide – OsS_2 – 254.32 – Dark bluish gray – Cubic – D 9.475 (673)

Oxygen – O (O_2) – 16.0000 – Colorless gas – M.P. —218.8 (14) (1026) – B.P. —182.963 (15)

Palladium – Pd – 106.7 – Steel white – Cubic – D 12.0^{20} (15) – M.P. 1554 (14) (1026) – B.P. 3980 (15)

Palladium (II) chloride – $PdCl_2$ – 177.61 – Rose red – Rhombic, cubic – D 4.00^{18} (54) – M.P. 500 (469)

Palladium (II) fluoride – PdF_2 – 144.70 – Brown – Tetragonal – D 5.82 (X-ray) (874)

Palladium (III) fluoride – PdF_3 – 163.70 – Black – Rhombic – D 5.06 (874)

Palladium (II) oxide – PdO – 122.70 – Black green – Tetragonal – D 8.70^{20} (638) – D.T. 877 (469)

Palladium (II) selenide – PdSe – 185.66 – M.P. < 960 (469)

Palladium (II) sulfide – PdS – 138.76 – Black – Tetragonal – D 6.69 (X-ray) (318) – M.P. 970 (1060)

Palladium (IV) sulfide – PdS_2 – 170.82 – Dark brown – D 4.833^{25} (86)

Phosphorus – P (Yellow) – 30.98 – Yellow – Cubic – D 1.82^{20} (15) – M.P. 44.1 (14) (1026) – B.P. 280 (15) – R.I. 2.117 (1075)

Phosphorus – P (Red) – 30.98 – Red – Monoclinic – D 2.20 (609) – M.P. 590 (43 atm.) (14) (1026) – B.P. 725 (463)

Phosphorus – P (Violet) – 30.98 – Violet – D 2.10^{20} (471) – S.P. 417 (519)

Phosphorus – P (Black) – 30.98 – Black – Graphite like – D 2.70 (471) – Transition to red P 550 (463) – S.P. 453 (519)

Phosphorus, Acids – See phosphorus oxide, hydrate

Phosphorus (III) chloride – PCl_3 – 137.35 – Colorless liquid – D 1.574^{21} (Liquid) (469) 2.015^{-183} (Solid) (92) – M.P. —92 (81) – B.P. 76 (762 mm.) (92) – R.I. 1.516^{14} (469)

Phosphorus (V) chloride – PCl_5 – 208.27 – Colorless – Tetragonal – D 2.114^{25} (92) – M.P. 163 (Closed tube) (971) – B.P. 162 (469)

Phosphorus (V) chloride oxide – $POCl_3$ – 153.35 – Colorless liquid – D 1.675 (Liquid) (469) 2.066^{-79} (Solid) (92) – M.P. 1.25 (469) – B.P. 108 (92) – R.I. 1.460^{25} (469)

Phosphorus (III) fluoride – PF_3 – 87.98 – Colorless gas – M.P. —151.5 (981) – B.P. —101.8 (981)

Phosphorus (V) fluoride – PF_5 – 125.98 – Colorless gas – M.P. —83 (469) – B.P. —75 (469)

Phosphorus (V) fluoride oxide – PF_3O – 103.98 – Colorless gas – M.P. —39.1 (785 mm.) (981) – B.P. —39.7 (981)

Phosphorus (III) oxide – P_4O_6 – 219.92 – Colorless – Monoclinic – D 2.135^{21} (469) – M.P. 23.8 (521) – B.P. 173 (519) – R.I. 1.5403 (675)

Phosphorus (III, V) oxide – $P_4O_6 \cdot P_4O_{10}$ – 503.84 – Colorless – Rhombic – D 2.537^{23} (469) – M.P. > 100 (469) – S.P. ~ 180 (469)

Phosphorus (V) oxide – P_4O_{10}(I) – 283.92 – Colorless – Rhombic – D 2.284^{20} (346) – M.P. 569 (521) – B.P. 591 (519)

Phosphorus (V) oxide – P_4O_{10}(II) – 283.92 – Colorless – Monoclinic or triclinic – D 2.420^{27} (167) – S.P. 358.9 (951) – R.I. 1.470-1.485 (167)

Phosphorus (V) oxide – P_4O_{10} (Amorphous) – 283.92 – Colorless – D 2.291^{27} (167)

Phosphorus (V) oxide – P_2O_5 (Glass) – 141.96 – Colorless – D 2.737^{27} (167) – R.I. 1.503 (569)

Phosphorus oxide – P_2O_7 – 173.96 – Dark violet – D.T. 130 (898)

Phosphorus (III) oxide, hydrate – $P_2O_3 \cdot 3H_2O$ – 164.00 – Colorless – D 1.651^{21} (469) – M.P. 73.6 (469)

Phosphorus (V) oxide, hydrate – $P_2O_5 \cdot H_2O$ (Glass) – 159.98 – Colorless – D 2.176^{-78} (80)

Phosphorus (V) oxide, hydrate – $P_2O_5 \cdot 2H_2O$ – 177.99 – Colorless – Needle – M.P. > 61 (675) – R.I. 1.3435 (675)

Phosphorus (V) oxide, hydrate – $P_2O_5 \cdot 3H_2O$ – 196.00 – Colorless – Rhombic – D 1.884^{18} (469) – M.P. 42.35 (609) – B.P. 122 (675)

Phosphorus (V) oxide, hydrate – $P_2O_5 \cdot 4H_2O$ – 214.02 – Colorless – M.P. 29.32 (857)

Phosphorus (V) oxide, hydrate – $2P_2O_5 \cdot 3H_2O$ – 337.97 – Colorless – D 1.889^{15} (819) – M.P. 34 (819)

Phosphorus (III) sulfide – P_4S_6 – 316.28 – Yellowish white – M.P. 290 (469) – B.P. 490 (469)

Phosphorus (V) sulfide – P_4S_{10} – 444.52 – Yellow – Cubic – D 2.062 (355) – M.P. 276 (469) – B.P. 514 (469) – R.I. > 1.8 (355)

Phosphorus (V) sulfide oxide – $P_2S_3O_2$ – 140.14 – Yellowish white – Acicular – M.P. 300 (469)

Phosphorus (V) sulfide oxide – $P_4S_4O_6$ – 348.16 – Colorless – Tetragonal – M.P. 102 (469) – B.P. 295 (469)

Platinum – Pt – 195.23 – Tin white – Cubic – D 21.45^{20} (15) – M.P. 1773.5 (14) (1026) – B.P. 4390 (15)

Platinum (II) chloride – $PtCl_2$ – 266.14 – Olive green – D 6.054^{25} (542) – D.T. 576 (599) – R.I. 1.98 (610)

Platinum (IV) chloride – $PtCl_4$ – 337.06 – Grayish brown – D 4.303^{25} (542)

Platinum (IV) oxide – PtO_2 – 227.23 – Black – D 10.2 (603)

Platinum (IV) phosphate – $PtO_2 \cdot P_2O_5$ – 369.27 – Pale greenish yellow – D 4.856 (469) – D.T. > 600 (469)

Platinum (IV) selenide – $PtSe_2$ – 353.15 – Gray – D 7.65 (469)

Platinum (VI) selenide – $PtSe_3$ – 432.11 – Black – D 7.15 (469)

Platinum (II) sulfide – PtS – 227.29 – Gray – D 10.1^{25} (82)

Platinum (IV) sulfide – PtS_2 – 259.35 – Gray – Trigonal – D 7.66 (82)

Polonium – Po – ~ 210 – Monoclinic – D 9.24 (X-ray) (855) – M.P. 600 (14) (1026)

Potassium – K – 39.096 – Silvery – Cubic – D 0.86^{20} (15) – M.P. 63 (14) (1026) – B.P. 774 (15)

Potassium aluminate – $K_2O \cdot Al_2O_3$ – 196.13 – Colorless – Cubic – M.P. > 1650 (144) – R.I. 1.603 (144)

Potassium aluminate – $K_2O \cdot 12Al_2O_3$ (Miscalled "Beta-Alumina") (838) – 1317.47 – Colorless – Hexagonal – D 3.370 (838) – D.T. 1650 (838) – R.I. o 1.670, e 1.639 (838)

Potassium aluminate borate – $K_2O \cdot 2Al_2O_3 \cdot 3B_2O_3$ (Nat. Rhodizite) – 507.00 – Colorless – Cubic – D 3.4 (469) – R.I. 1.69 (469)

Potassium aluminate fluoride – $2KF \cdot AlF_3$ – 200.17 – Rhombic and monoclinic – R.I. > 1.34, < 1.445 (1013)

Potassium aluminate fluoride – $3KF \cdot AlF_3$ – 258.27 – Colorless – M.P. 1025 – T.P. 300 (272) (469)

Potassium aluminate phosphate – $K_2O \cdot Al_2O_3 \cdot 2P_2O_5$ – 480.21 – Colorless – Monoclinic – D 2.8 (756)

Potassium aluminate phosphate – $3K_2O \cdot 2Al_2O_3 \cdot 3P_2O_5$ – 912.57 – Colorless – Monoclinic – D 2.3^{20} (756)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot SiO_2$ – 256.19 – Colorless – Cubic – R.I. 1.540 (120)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot 2SiO_2$(I) (Kaliophilite) – 316.25 – Colorless – Rhombic – M.P. 1800 (120) – R.I. p 1.528, m 1.535, g 1.536 (120)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot 2SiO_2$(II) (Kaliophilite) – 316.25 – Colorless – Hexagonal – D 2.6 (469) – Transition to I 1550 (469) – R.I. o 1.532, e 1.527 (120)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot 2SiO_2$ (Glass) – 316.25 – Colorless – R.I. 1.508 (120)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot 4SiO_2$(I) (Leucite) – 436.37 – Colorless – Cubic – D 2.47 (469) – M.P. 1686 (125) – R.I. 1.508 (125)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot 4SiO_2$(II) (Leucite) – 436.37 – Colorless – Tetragonal – D 2.507 (715) – Transition to I 620 (675) – R.I. p 1.508, m 1.508, g 1.509 (120)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot 4SiO_2$ (Glass) – 436.37 – Colorless – D 2.44 (960) – R.I. 1.490 (120)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot 6SiO_2$ (Orthoclase) – 556.49 – Colorless – Monoclinic – D 2.56 (469) – M.P. 1170 (Incong.) (469) – R.I. p 1.518, m 1.524, g 1.526 (469)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot 6SiO_2$ (Microcline) – 556.49 – Colorless – Triclinic – D 2.56 (469) – M.P. 1150 (469) – R.I. p 1.522, m 1.526, g 1.530 (469)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot 6SiO_2$ (Nat. Adular) – 556.49 – D 2.575 (236) – M.P. 1145 (716)

Potassium aluminate silicate – $K_2O \cdot Al_2O_3 \cdot 6SiO_2$ (Glass) – 556.49 – Colorless – D 2.370 (236)

Potassium aluminate silicate, hydrate – $K_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$ (Nat. Muscovite) – 796.40 – Colorless – Monoclinic – D 2.9 (469) – R.I. p 1.561, m 1.590, g 1.594 (469)

Potassium aluminum sulfate – $K_2SO_4 \cdot Al_2(SO_4)_3$ – 516.37 – Colorless – Hexagonal – D 2.75^{20} (899) – D.T. 718 (588) – R.I. o 1.545, e 1.533 (1075)

Potassium aluminum sulfate hydroxide – $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 4Al(OH)_3$ (Alunite) – 828.33 – Colorless – Trigonal – D 2.60 (469) – R.I. o 1.572, e 1.592 (469)

Potassium aluminum sulfate, hydrate – $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ (Alum) – 948.76 – Colorless – Cubic – D 1.74 (588) – R.I. 1.4562 (1066)

Potassium aluminum sulfate, hydrate – $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ (Kalmite) – 948.76 – Colorless – Hexagonal – D 1.75 (469) – R.I. o 1.456, e 1.429 (1075)

Potassium aluminum sulfate, hydrate – $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ – 948.76 – Colorless – Monoclinic – R.I. p 1.430, m 1.452, g 1.458 (469)

Potassium antimonate, fluo- – $KF \cdot SbF_5$ – 274.86 – Rhombic – D 3.84^{17} (613) – D.T. 285 (613) – R.I. p –, m 1.362, g – (613)

Potassium arsenate, hydrate – $K_2O \cdot As_2O_5 \cdot 2H_2O$ – 360.04 – Colorless – Tetragonal – D 2.867 (469) – M.P. 288 (469) – R.I. o 1.567, e 1.518 (469)

Potassium barium carbonate – $K_2CO_3 \cdot BaCO_3$ – 335.57 – M.P. 800 (469)

Potassium barium phosphate – $K_2O \cdot 2BaO \cdot P_2O_5$(I) – 542.85 – Colorless – Tetragonal – D 4.34 (544) (972)

Potassium barium phosphate – $K_2O \cdot 2BaO \cdot P_2O_5$(II) – 542.85 – Colorless – Rhombic – D 3.97 (X-ray) (544) (972)

Potassium beryllium fluoride – $2KF \cdot BeF_2$ – 163.22 – Colorless – Rhombic – M.P. Red heat (348)

Potassium beryllium silicate – $K_2O \cdot 3BeO \cdot 4SiO_2$ – 409.49 – Cubic – D 2.531 (320) – R.I. 1.523 (320)

Potassium beryllium silicate – $2K_2O \cdot 3BeO \cdot 6SiO_2$ (Glass) – 623.80 – Colorless – D 2.478 (606) – R.I. 1.5201 (606)

Potassium borate – $K_2O \cdot B_2O_3$ – 163.83 – Colorless – Hexagonal – D 2.348 (1107) – M.P. 968 (202) – R.I. o 1.526, e 1.450 (202)

Potassium borate – $K_2O \cdot 2B_2O_3$ – 233.47 – Colorless – M.P. 815 (852)

Potassium borate – $K_2O \cdot 4B_2O_3$ – 372.75 – Colorless – M.P. 857 (852)

Potassium borate – $K_2O \cdot 5B_2O_3$(I) – 442.39 – M.P 780 (Incong.) (853)

Potassium borate – $K_2O \cdot 5B_2O_3$(II) – 442.39 – Colorless – M.P. 760 (Incong.) – Transition to I 720 (853)

Potassium borate – $K_2O \cdot 5B_2O_3$(III) (Metastable low temp. form) – 442.39 – Transition to I 690 (853)

Potassium borate, fluo- – $KF \cdot BF_3$(I) – 125.92 – Colorless – Cubic – M.P. 530 (105)

Potassium borate, fluo- – $KF \cdot BF_3$(II) – 125.92 – Colorless – Rhombic – D 2.50 (469) – Transition to I 278 (1037) – R.I. p 1.324, m 1.325, g 1.325 (1112)

Potassium borate phosphate – See potassium phosphate borate

Potassium bromide – KBr – 119.01 – Colorless – Cubic – D 2.75 (469) – M.P. 742 (521) – B.P. 1383 (519) – R.I. $1.55945^{18°}$ (954)

Potassium cadmium phosphate – $K_2O \cdot 2CdO \cdot P_2O_5$ – 493.05 – Colorless – Rhombic – D 3.8 (469)

Potassium calcium aluminum silicate, hydrate – $K_2O \cdot 2CaO \cdot 3Al_2O_3 \cdot 10SiO_2 \cdot 12H_2O$ (Nat. Christianite) – 1328.96 – D 2.204 (1090)

Potassium calcium aluminum silicate, hydrate – $K_2O \cdot 4CaO \cdot 2Al_2O_3 \cdot 24SiO_2 \cdot H_2O$ (Nat. Milarite) – 1981.85 – Hexagonal – D 2.57 (469) – R.I. o 1.532, e 1.529 (469)

Potassium calcium carbonate – $K_2CO_3 \cdot CaCO_3$ – 238.29 – Colorless – Rhombic – D 2.465 (255) – M.P. 813 (760 mm.) (255) – R.I. o 1.530, e 1.48 (255)

Potassium calcium phosphate – $K_2O \cdot CaO \cdot P_2O_5$ – 292.31 – Hexagonal – D 2.7 (469)

Potassium calcium phosphate – $K_2O \cdot 2CaO \cdot P_2O_5$ (Rhenanite) – 348.39 – Colorless – Hexagonal – D 2.32 (X-ray) (544) (972) – T.P. 705 (300)

Potassium calcium silicate – $K_2O \cdot CaO \cdot SiO_2$ – 210.33 – Colorless – Hexagonal – M.P. 1630 (708) – R.I. o 1.600, e 1.605 (708)

Potassium calcium silicate – $K_2O\cdot 2CaO\cdot 9SiO_2$ – 746.89 – Colorless – Monoclinic or triclinic – M.P. 1050 (Incong.) (708) – R.I. p 1.515, m –, g 1.535 (708)

Potassium calcium silicate – $K_2O\cdot 3CaO\cdot 6SiO_2$(I) – 622.79 – Colorless – Rhombic – M.P. 1115 (Incong.) (708) – R.I. p 1.575, m –, g 1.59 (708)

Potassium calcium silicate – $K_2O\cdot 3CaO\cdot 6SiO_2$(II) – 622.79 – Colorless – Rhombic – M.P. 1020 (708) – R.I. p 1.56, m –, g 1.57 (708)

Potassium calcium silicate – $K_2O\cdot 23CaO\cdot 12SiO_2$ – 2104.75 – Colorless – R.I. p 1.695, m –, g 1.703 (989)

Potassium calcium silicate – $2K_2O\cdot CaO\cdot 3SiO_2$ – 434.64 – Pseudocubic – M.P. 1005 (708) – R.I. 1.572 (708)

Potassium calcium silicate – $2K_2O\cdot CaO\cdot 6SiO_2$ – 614.82 – Colorless – Monoclinic or triclinic – M.P. 959 (708) – R.I. p 1.540, m 1.541, g 1.544 (708)

Potassium calcium silicate – $4K_2O\cdot CaO\cdot 10SiO_2$ – 1033.44 – Colorless – Hexagonal – M.P. 946 (708) – R.I. p 1.537, m –, g 1.548 (708)

Potassium calcium silicate, hydrate – $K_2O\cdot 8CaO\cdot 16SiO_2\cdot 16H_2O$ (Nat. Apophyllite) – 1792.05 – Tetragonal – D 2.35 (469) – R.I. o 1.537, e 1.535 (469)

Potassium calcium sulfate – $K_2SO_4\cdot 2CaSO_4$ – 446.53 – Colorless – Cubic – D 2.63 (X-ray) (821) (972)

Potassium carbonate – K_2CO_3 – 138.20 – Colorless – 4 Modifications – D 2.428^{19} (457) – M.P. 897 (521) – T.P. 250, 428, 622 (658) – R.I. p 1.426, m 1.531, g 1.541 (1075)

Potassium carbonate, bi- – $KHCO_3$ – 100.11 – Colorless – Monoclinic – D 2.1 (348) – D.T. 173 (760 mm.) (520) – R.I. p 1.380, m 1.482, g 1.578 (469)

Potassium carbonate, hydrate – $K_2O\cdot 2CO_2\cdot H_2O$ (Nat. Kalicinite) – 200.23 – Monoclinic – D 2.17 (469) – D.T. < 200 (469) – R.I. p –, m 1.482, g – (469)

Potassium carbonate, hydrate – $2K_2CO_3\cdot 3H_2O$ – 330.45 – Colorless – Monoclinic – D 2.043 (469)

Potassium carbonate fluoride – $K_2CO_3\cdot KF$ – 196.30 – Colorless – M.P. 683 (1035)

Potassium chlorate – $KClO_3$ – 122.55 – Colorless – Monoclinic – D 2.338^{21} (457) – M.P. 357.1 (172) – R.I. p 1.410, m 1.517, g 1.524 (1104)

Potassium chlorate, per- – $KClO_4$(I) – 138.55 – Colorless – Cubic – D 2.18 (X-ray) (421) – M.P. 525 (348)

Potassium chlorate, per- – $KClO_4$(II) – 138.55 – Colorless – Rhombic – D 2.5298 (1086) – Transition to I 299.5 (1038) – R.I. p 1.4717, m 1.4724, g 1.4759 (1086)

Potassium chloride – KCl – 74.55 – Colorless – Cubic – D 1.9890 (1087) – M.P. 770 (521) – B.P. 1407 (519) – R.I. 1.49042^{18° (1086)

Potassium chromate – $K_2O\cdot CrO_3$(I) – 194.20 – Red – Hexagonal – M.P. 984 (521)

Potassium chromate – $K_2O\cdot CrO_3$(II) (Tarapacaite) – 194.20 – Yellow – Rhombic – D 2.732^{18} (23) – Transition to I 666 (375) – R.I. p 1.7087, m 1.7261, g 1.7304 (205)

Potassium chromate, di- – $K_2O\cdot 2CrO_3$ – 294.21 – Orange red – Monoclinic and triclinic – D 2.69 (469) – M.P. 397.4 – T.P. 241.6 (635) – R.I. p 1.7202, m 1.7380, g 1.8197 (469)

Potassium chromate, tri- – $K_2O\cdot 3CrO_3$ – 394.22 – Red – Monoclinic – D 2.648^{10} (469) – M.P. 250 (469)

Potassium chromate, tetra- – $K_2O\cdot 4CrO_3$ – 494.23 – Red – Monoclinic – D 2.649^{11} (469) – M.P. 215 (469)

Potassium chromium (III) fluoride – $3KF\cdot CrF_3$ – 283.30 – D 2.93^{0} (239)

Potassium chromium (III) phosphate – $K_2O\cdot Cr_2O_3\cdot 2P_2O_5$ – 530.29 – Monoclinic – D 3.5 (469)

Potassium chromium (VI) selenate – $K_2O\cdot CrO_3\cdot SeO_3$ – 321.16 – M.P. 120 (469)

Potassium chromium (VI) sulfate – $K_2O\cdot CrO_3\cdot SO_3$ – 274.26 – M.P. 350 (469)

Potassium cobalt (II) fluoride – $2KF\cdot CoF_2$ – 213.13 – Monoclinic – D 3.22 (469)

Potassium columbate – $K_2O\cdot Cb_2O_5$ – 360.01 – Cubic – D 4.634 (X-ray) (815)

Potassium columbian fluoride – $2KF\cdot CbF_5$ – 304.10 – Monoclinic – D 3.21 (1117)

Potassium cyanate – $KCNO$ – 81.11 – Colorless – Tetragonal – D 2.056^{20} (207)

Potassium cynanide – KCN – 65.11 – Colorless – Cubic – D 1.560^{25} (68) – M.P. 623 (521) – T.P. —60 (65) – R.I. 1.410 (1075)

Potassium cyanide, seleno- – $KCNSe$ – 144.07 – Needle – D 2.347^{20} (467) – D.T. 100 (210)

Potassium cyanide, thio- – $KCNS$(I) – 97.17 – M.P. 176.8 (575)

Potassium cyanide, thio- – $KCNS$(II) – 97.17 – Colorless – Rhombic – D 1.882^{20} (467) – Transition to I 140.6 (575) – R.I. p 1.532, m 1.660, g 1.730 (1075)

Potassium fluoride – KF – 58.10 – Colorless – Cubic – D 2.505^{25} (1086) – M.P. 857 (521) – B.P. 1502 (519) – R.I. 1.36290^{25° (1086)

Potassium fluoride, hydrate – $KF \cdot 2H_2O$ – 94.13 – Colorless – Monoclinic – M.P. 41 (294) – R.I. p 1.345, m 1.352, g 1.363 (1075)

Potassium fluoride, acid- – $KF \cdot HF$ – 78.10 – Colorless – M.P. 239 (162) – T.P. 195 (162)

Potassium fluoride, acid- – $KF \cdot 2HF$ – 98.11 – Colorless – M.P. 71.7 (162)

Potassium fluoride, acid- – $KF \cdot 3HF$ – 118.12 – Colorless – M.P. 65.8 (162)

Potassium fluoride, acid- – $KF \cdot 4HF$ – 138.12 – Colorless – M.P. 72.0 (162)

Potassium fluoride, acid- – $2KF \cdot 5HF$ – 216.24 – Colorless – M.P. 64.3 (162)

Potassium formate – $K \cdot HCO_2$ – 84.11 – Colorless – Rhombic – D 1.91 (469) – M.P. 167.5 (469)

Potassium germanate – $K_2O \cdot GeO_2$ – 198.79 – Colorless – D $3.40^{21.5}$ (921) – M.P. 842 (919)

Potassium germanate – $K_2O \cdot 2GeO_2$ – 303.39 – Colorless – D $4.31^{21.5}$ (921) – M.P. 797 (919)

Potassium germanate – $K_2O \cdot 4GeO_2$ – 512.59 – Colorless – D $4.12^{21.5}$ (921) – M.P. 1038 (919)

Potassium germanium fluoride – $2KF \cdot GeF_4$ – 264.80 – White – Hexagonal – D 3.32 (438) – M.P. 730 (714) – B.P. 835 (714)

Potassium hafnium fluoride – $2KF \cdot HfF_4$ – 370.8 – Monoclinic – R.I. p 1.461, m –, g 1.449 (469)

Potassium hafnium fluoride – $3KF \cdot HfF_4$ – 428.9 – Cubic – R.I. 1.403 (469)

Potassium hydroxide – KOH – 56.10 – Colorless – Rhombic, cubic – D 2.12 (557) – M.P. 360 (521) – T.P. 248 (422) – B.P. 1327 (519) – R.I. 1.422^{380° (687)

Potassium iodide – KI – 166.02 – Colorless – Cubic – D 3.123^{25} (469) – M.P. 682 (521) – B.P. 1324 (519) – R.I. 1.6670 (954)

Potassium iron (II) cyanide – $K_4Fe(CN)_6$ – 368.33 – Yellow – Monoclinic – D 1.935^{25} (68) – R.I. p 1.5752, m –, g 1.5815 (348)

Potassium iron (III) cyanide – $K_3Fe(CN)_6$ – 329.24 – Orange – Monoclinic – D 1.858^{25} (68) – D.T. 208 (496) – R.I. p 1.5660, m 1.5689, g 1.5831 (469)

Potassium iron (III) fluoride – $3KF \cdot FeF_3$ – 248.05 – Colorless – Cubic – D 2.20 (694)

Potassium iron (III) oxide – $K_2O \cdot Fe_2O_3$ – 253.87 – D 3.417 (433)

Potassium iron (III) silicate – $K_2O \cdot Fe_2O_3 \cdot 4SiO_2$(I) (Iron Leucite) – 494.11 – Yellow – Pseudocubic – D 2.59 (320) – M.P. 1050 (Incong.) (269) – R.I. p –, m 1.619, g – (320)

Potassium iron (III) silicate – $K_2O \cdot Fe_2O_3 \cdot 4SiO_2$(II) – 494.11 – Monoclinic – R.I. p –, m 1.80, g – (319)

Potassium iron (III) silicate – $K_2O \cdot Fe_2O_3 \cdot 6SiO_2$ (Iron Orthoclase) – 614.23 – Yellow – Monoclinic or triclinic – M.P. 920 (Incong.) (269) – R.I. p 1.601, m –, g 1.609 (319)

Potassium iron (III) sulfide – $K_2S \cdot Fe_2S_3$ – 318.12 – Hexagonal – D 2.66 (747)

Potassium lanthanum silicate – $K_2O \cdot La_2O_3 \cdot 2SiO_2$ – 540.15 – Colorless – Hexagonal – R.I. o 1.867, e 1.840 (256)

Potassium lead (II) silicate – $K_2O \cdot PbO \cdot 4SiO_2$ – 557.64 – Rectangular plate – M.P. 757 (325) – R.I. p 1.590, m 1.612, g 1.650 (325)

Potassium lead (II) silicate – $K_2O \cdot 2PbO \cdot 2SiO_2$ – 660.73 – Hexagonal – D 5.15 (669) – M.P. 918 (325) – R.I. o 1.93, e 1.72 (325)

Potassium lead (II) silicate – $K_2O \cdot 4PbO \cdot 8SiO_2$ – 1467.51 – Fiber – M.P. 779 (325) – R.I. p 1.69, m –, g 1.69 (325)

Potassium lead (II) silicate – $2K_2O \cdot PbO \cdot 3SiO_2$ – 497.58 – M.P. 735 (325) – R.I. p 1.665, m –, g 1.685 (325)

Potassium lead (II) sulfate – $K_2Pb(SO_4)_2$ (Nat. Palmierite) – 477.52 – Rhombic – R.I. o 1.712, e – (1111)

Potassium lithium carbonate – $KLiCO_3$ – 106.05 – M.P. 515 (469)

Potassium lithium sulfate – $KLiSO_4$ – 142.10 – Hexagonal – D 2.393 (469) – M.P. 716 (348) – R.I. o 1.4715, e 1.4721 (469)

Potassium lithium tungstate – $K_2O \cdot Li_2O \cdot WO_3$ – 356.00 – M.P. 632 (643)

Potassium magnesium aluminum silicate, hydrate – $K_2O \cdot 2MgO \cdot Al_2O_3 \cdot 10SiO_2 \cdot 7H_2O$ (Nat. Bondsdorffite) – 1003.487 – Colorless – D 2.65 (782) – R.I. p 1.563, m 1.568, g 1.568 (782)

Potassium magnesium aluminum silicate, hydrate – $K_2O \cdot 6MgO \cdot Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$ (Phlogopite) – 834.44 – Monoclinic – D 2.85 (617) – R.I. p 1.520, m –, g 1.558 (371)

Potassium magnesium carbonate – $K_2CO_3 \cdot MgCO_3$ – 222.53 – D 2.671 (255) – R.I. o 1.597, e 1.47 (255)

Potassium magnesium carbonate – $K_2CO_3 \cdot MgCO_3$ (Glass) – 222.53 – Colorless – D 2.390 (255) – R.I. 1.496 (255)

Potassium magnesium fluoride – $KF \cdot MgF_2$ – 120.42 – Colorless – Tetragonal – D 2.8 (238) – M.P. 1080 (831)

Potassium magnesium fluoride – $2KF \cdot MgF_2$ – 178.52 – Colorless – D 2.7 (469)

Potassium magnesium phosphate – $K_2O \cdot 2MgO \cdot P_2O_5$ – 316.87 – Rhombic – D 2.6 (469)

Potassium magnesium sulfate – $K_2Mg_2(SO_4)_3$ (Langbeinite) – 415.01 – Colorless – Cubic – D 2.83 (617) – M.P. 930 (363) – R.I. 1.533 (617)

Potassium manganate, per- – $KMnO_4$ – 158.03 – Purple – Rhombic – D 2.698^{18} (457) – D.T. <240 (469) – R.I. o 1.59, e – (469)

Potassium manganese (II) sulfate – $K_2Mn_2(SO_4)_3$ (Nat. Manganolangbeinite) – 476.23 – Rose red – Cubic – D 3.02 (617) – R.I. 1.572 (617)

Potassium molybdate – $K_2O \cdot MoO_3$(I) – 238.14 – Colorless – M.P. 922 (521)

Potassium molybdate – $K_2O \cdot MoO_3$(II) – 238.14 – Colorless – Transition to I 480 (447)

Potassium molybdate – $K_2O \cdot MoO_3$(III) – 238.14 – Colorless – Transition to II 458 (447)

Potassium molybdate – $K_2O \cdot MoO_3$(IV) – 238.14 – Colorless – D 2.91^{18} (53) – Transition to III 323 (447)

Potassium molybdate – $K_2O \cdot 2MoO_3$ – 382.09 – M.P. 484 (11)

Potassium nitrate – KNO_3(I) – 101.10 – Colorless – Trigonal – D 2.033^{128} (196) – M.P. 338 (521) – D.T. 400 (469)

Potassium nitrate – KNO_3(II) – 101.10 – Colorless – Rhombic – D 2.098^{18} (457) – Transition to I 128 (518) – R.I. p 1.3320, m 1.5038, g 1.5042 (469)

Potassium nitrate, hydroxy- – $KNO_3 \cdot 2KOH$ – 213.30 – Colorless – M.P. 232 (835)

Potassium nitrate, acid- – $KNO_3 \cdot 2HNO_3$ – 227.14 – Colorless – M.P. 22 (469)

Potassium nitrate chloride – $KNO_3 \cdot KCl$ – 175.65 – Colorless – M.P. 360 (Incong.) (860)

Potassium nitrite – KNO_2 – 85.10 – Colorless – Monoclinic – D 1.926 (157) – M.P. 441 (157) – T.P. 47 (157) – D.T. 460 (157)

Potassium oxalate, acid- – KHC_2O_4 – 128.12 – Colorless – Monoclinic – D 2.066 (411) – R.I. p 1.382, m 1.553, g 1.573 (411)

Potassium oxide – K_2O – 94.19 – Colorless – Cubic – D 2.32 (469) – D.T. 881 (600 mm.) (636)

Potassium oxide, per- – K_2O_2 – 110.19 – Colorless or slight yellow – M.P. 490 (175) – D.T. 779 (760 mm.) (175)

Potassium phosphate, meta- – $K_2O \cdot P_2O_5$ – 236.23 – Colorless – D 2.258^{15} (469) – M.P. 817 (521) – T.P. 450 (469) – B.P. 1320 (648)

Potassium phosphate, pyro- – $2K_2O \cdot P_2O_5$ – 330.42 – Colorless – D 2.33 (469) – M.P. 1092 (521) – T.P. 278 (469)

Potassium phosphate, ortho- – $3K_2O \cdot P_2O_5$ – 424.62 – Colorless – Needle – D 2.564^{17} (457) – M.P. 1320 (521)

Potassium phosphate, hydrate – $K_2O \cdot P_2O_5 \cdot 2H_2O$ – 272.26 – Colorless – Tetragonal – D 2.338 (469) – M.P. 253 (685) – R.I. o 1.5095, e 1.4684 (469)

Potassium phosphate, hydrate – $2K_2O \cdot P_2O_5 \cdot 7H_2O$ – 456.53 – Colorless – Monoclinic – D 2.026^{25} (28)

Potassium phosphate, hydrate – $3K_2O \cdot P_2O_5 \cdot 16H_2O$ – 712.88 – Colorless – Rectangular plates – M.P. 45.1 (488)

Potassium phosphate, fluo- – $KF \cdot PF_5$ – 184.08 – Cubic – D 2.591^{18} (614)

Potassium phosphate borate – $2K_2O \cdot B_2O_3 \cdot P_2O_5$ – 400.06 – Colorless – Trigonal – M.P. 872 (469)

Potassium platinum (IV) chloride – $2KCl \cdot PtCl_4$ – 486.16 – Yellow – Cubic – D 3.474 (542) – D.T. 250 (469) – R.I. 1.827 (5770Å) (1075)

Potassium rhenate – $K_2O \cdot Re_2O_7$ – 409.60 – Black – Tetragonal – D 4.887 (X-ray) (138) – M.P. 552 (1036) – B.P. 1370 (1036) – R.I. o 1.643, e 1.673 (654)

Potassium selenate – $K_2O \cdot SeO_3$ – 221.15 – Colorless – Rhombic – D 3.066 (469) – R.I. p 1.5352, m 1.5390, g 1.5446 (469)

Potassium selenate sulfate – $K_2O \cdot SeO_3 \cdot SO_3$ – 301.21 – M.P. 12 (469)

Potassium selenide – K_2Se – 157.15 – Colorless – Cubic – D 2.851 (469)

Potassium silicate – $K_2O \cdot SiO_2$ – 154.25 – Colorless – Rhombic – M.P. 976 (469) – R.I. p 1.520, m –, g 1.528 (579)

Potassium silicate – $K_2O \cdot 2SiO_2$ – 214.31 – Colorless – Rhombic – D 2.538^{25} (357) – M.P. 1045 – T.P. 594 (580) – R.I. p 1.503, m –, g 1.513 (580)

Potassium silicate – $K_2O \cdot 2SiO_2$ (Glass) – 214.31 – Colorless – D 2.474^{25} (357) – R.I. 1.51 ± (713)

Potassium silicate – $K_2O \cdot 4SiO_2$ – 334.43 – Colorless – Monoclinic or triclinic – D 2.335^{25} (357) – M.P. 770 (580) – T.P. 592 (357) – R.I. p 1.477, m –, g 1.482 (579)

Potassium silicate – $K_2O \cdot 4SiO_2$ (Glass) – 334.43 – Colorless – D 2.384^{25} (357) – R.I. 1.495 (357)

Potassium silicate, hydrate – $K_2O \cdot SiO_2 \cdot H_2O$ – 172.27 – Colorless – R.I. p –, m 1.50, g – (700)

Potassium silicate, hydrate – $K_2O \cdot 2SiO_2 \cdot H_2O$ – 232.33 – Colorless – Granular – R.I. p –, m 1.50, g – (700)

Potassium silicate, hydrate – $K_2O \cdot 4SiO_2 \cdot H_2O$ – 352.45 – Rhombic – D 2.417 (700) – M.P. 515 (701) – R.I. p 1.480-1.495, m –, g 1.530-1.535 (700)

Potassium silicate, hydrate – $K_2O \cdot 4SiO_2 \cdot H_2O$ – 352.45 – Rhombic – D 2.417 (469) – D.T. 400 (469) – R.I. p 1.495, m 1.535, g – (469)

Potassium silicate, hydrate – $2K_2O \cdot 2SiO_2 \cdot H_2O$ – 326.52 – Colorless – Granular – R.I. p –, m $\sim$ 1.50, g – (700)

Potassium silicate, fluo- – $2KF \cdot SiF_4$ – 220.25 – Colorless – Cubic – D 2.665 (469) – R.I. 1.3991 (818)

Potassium silicate, fluo- – $2KF \cdot SiF_4$ – 220.25 – Colorless – Hexagonal – D 3.081 (359)

Potassium sodium sulfate – $3K_2SO_4 \cdot Na_2SO_4$ (Glaserite) – 664.81 – Trigonal – D 2.696 (469) – M.P. $<$ 1000 (469) – T.P. 431 (718) – R.I. o 1.4901, e 1.4996 (469)

Potassium sodium aluminum silicate, hydrate – $K_2O \cdot Na_2O \cdot 4Al_2O_3 \cdot 8SiO_2 \cdot 4H_2O$ (Nat. Igalikite) – 1116.46 – Hexagonal – D 2.559 (106) – R.I. o $>$ e, e 1.540 (106)

Potassium strontium phosphate – $K_2O \cdot SrO \cdot P_2O_5$ – 339.86 – Hexagonal – D 2.9 (469)

Potassium strontium phosphate – $K_2O \cdot 2SrO \cdot P_2O_5$(I) – 443.49 – Colorless – Tetragonal – D 3.98 (X-ray) (544) (972)

Potassium strontium phosphate – $K_2O \cdot 2SrO \cdot P_2O_5$(II) – 443.49 – Colorless – Hexagonal – D 2.90 (X-ray) (544) (972)

Potassium sulfate – K_2SO_4(I) – 174.25 – Colorless – Hexagonal – M.P. 1069.1 (845) – B.P. 1700 (648)

Potassium sulfate – K_2SO_4(II) – 174.25 – Colorless – Rhombic – D 2.662 (469) – Transition to I 583 (845) – R.I. p 1.49333, m 1.49456, g 1.49733 (all at 20°) (1086)

Potassium sulfate – $K_2O \cdot 2SO_3$ – 254.31 – Colorless – Prism – D 2.512^{25} (165) – M.P. 414.2 (165) – T.P. 225, 315 (165)

Potassium sulfate – $K_2O \cdot 3SO_3$ – 334.37 – Colorless – D.T. 150 (47)

Potassium sulfate, acid- – $KHSO_4$ (Misenite) – 136.16 – Colorless – Rhombic, monoclinic – D 2.35 (469) – M.P. 218.6 (529) – T.P. 182, 202 (529) – R.I. p 1.475, m 1.480, g 1.488 (617)

Potassium sulfate, acid- – $K_3H(SO_4)_2$ – 310.41 – Colorless – Monoclinic – D 2.59^{18} (469) – R.I. p 1.479, m 1.490, g 1.526 (469)

Potassium sulfate, acid- – KHS_2O_7 – 216.22 – Colorless – M.P. 168 (469)

Potassium sulfide – K_2S – 110.25 – Colorless – Cubic – D 1.74 (1124) – M.P. 912 (361) – T.P. 146.4 (469)

Potassium sulfide, di- – K_2S_2 – 142.31 – Reddish yellow – M.P. 470 (994)

Potassium tantalate – $K_2O \cdot Ta_2O_5$ – 535.95 – Cubic – D 7.022 (X-ray) (815)

Potassium tantalum fluoride – $2KF \cdot TaF_5$ – 392.07 – Colorless – Monoclinic (437) – D 4.56 (469)

Potassium tantalum silicate – $8K_2O \cdot Ta_2O_5 \cdot 16SiO_2$ (Glass) – 2156.24 – Colorless – D 2.885 (973) – R.I. 1.541 (973)

Potassium telluride – K_2Te – 205.80 – Colorless – Cubic – D 2.52 (1124)

Potassium thorium phosphate – $K_2O \cdot 4ThO_2 \cdot 3P_2O_5$ – 1576.79 – Colorless – Prismatic – D 5.75^{12} (675)

Potassium titanate – $K_2O \cdot TiO_2$ – 174.09 – M.P. 810 (521)

Potassium titanate – $K_2O \cdot 2TiO_2$ – 253.99 – Rhombic – M.P. 980 (469) – R.I. p –, m $>$ 1.74, g – (735)

Potassium titanium fluoride – $2KF \cdot TiF_4$ – 240.09 – Trigonal – D 3.012^{15} (1117) – M.P. 780 (339) – R.I. o 1.475, e $<$ o (1117)

Potassium tungstate – $K_2O \cdot WO_3$ – 326.11 – Colorless – Monoclinic – D 3.120^{991} (469) – M.P. 927 (521) – T.P. 338 (447)

Potassium tungstate – $K_2O \cdot 2WO_3$ – 558.03 – M.P. 555 (469)

Potassium tungstate – $K_2O \cdot 8WO_3$ – 1949.55 – Steel gray – D 6.53 (469)

Potassium uranyl nitrate – $K_2(UO_2)(NO_3)_4$ – 596.29 – Green – Monoclinic – D 3.36 (731) – R.I. p 1.5349, m –, g 1.5422 (731)

Potassium vanadate – $K_2O \cdot V_2O_5$ – 276.10 – Pale yellow – M.P. 515 (666)

Potassium zirconium fluoride – $2KF \cdot ZrF_4$ – 283.41 – Colorless – Monoclinic – D 3.58 (531) – R.I. p 1.454, m 1.465, g 1.498 (531)

Praseodymium – Pr – 140.92 – Hexagonal – D 6.63^{20} (15) – M.P. 940 (14) (1026)

Praseodymium chloride – $PrCl_3$ – 247.29 – Bluish green – Needle – D 4.15^{25} (540) – M.P. 823 (540) – B.P. $>$ 1000 (1034)

Praseodymium fluoride – PrF_3 – 197.92 – Yellow – Hexagonal – D 6.33 (X-ray) (751)

Praseodymium molybdate – $Pr_2O_3 \cdot 3MoO_3$ – 758.99 – Grass green – Tetragonal – D 4.84^{17} (675) – M.P. 1030 (675) – R.I. o –, e 2.007 (5700A) (1113)
Praseodymium nitrate, hydrate – $Pr(NO_3)_3 \cdot 6H_2O$ – 435.04 – Green – Triclinic – M.P. 56 (Incong.) (312)
Praseodymium oxide – Pr_2O_3 – 329.84 – Yellow – Hexagonal, trigonal – D 6.94^{20} (808)
Praseodymium oxide – Pr_4O_7 – 675.68 – D 6.715 (469)
Praseodymium oxide – Pr_6O_{11} – 1021.52 – Dark brown – D 6.61^{20} (808)
Praseodymium oxide – $Pr_{10}O_{18}$ – 1697.20 – D 6.704 (469)
Praseodymium (IV) oxide – PrO_2 – 172.92 – Black – D 6.82^{20} (808) – D.T. > 350 (808)
Praseodymium selenate – $Pr_2O_3 \cdot 3SeO_3$ – 710.72 – D 4.30^{15} (469)
Praseodymium selenate, hydrate – $Pr_2O_3 \cdot 3SeO_3 \cdot 8H_2O$ – 854.85 – D 3.094^{14} (469)
Praseodymium selenide – Pr_2Se_3 – 518.72 – Red – D 6.48 (551)
Praseodymium (IV) selenide – Pr_2Se_4 – 597.78 – D 6.64 (551)
Praseodymium silicate – $Pr_2O_3 \cdot SiO_2$ – 389.90 – Green (960)
Praseodymium sulfate – $Pr_2(SO_4)_3$ – 570.02 – Light green – D 3.720^{16} (469) – D.T. 1010 (659) (765)
Praseodymium sulfate, hydrate – $Pr_2(SO_4)_3 \cdot 5H_2O$ – 660.10 – Monoclinic – D 3.173 (469)
Praseodymium sulfate, hydrate – $Pr_2(SO_4)_3 \cdot 8H_2O$ – 714.15 – Green – Monoclinic – D 2.813^{20} (424) – M.P. 75 (675) – —$8H_2O$ at 450 (765) – R.I. p 1.5399, m 1.5494, g 1.5607 (469)
Praseodymium sulfide – Pr_2S_3 – 378.02 – Chocolate brown – D 5.25^{25} (552)
Protoactinium – Pa – 231 – M.P. 3000 (14) (1026)
Radium – Ra – 226.05 – Brilliant white – D 5.0^{20} (15) – M.P. 700 (14) (1026) – B.P. 1140 (15)
Radium chloride – $RaCl_2$ – 296.96 – Bluish violet – Monoclinic – D 4.91 (469) – M.P. 1000 (469)
Radium fluoride – RaF_2 – 264.05 – Cubic – D 6.75 (X-ray) (912)
Rhenium – Re – 186.31 – Hexagonal – D 20^{20} (15) – M.P. 3000 (14) (1026) – B.P. 5870 (15)
Rhenium (IV) fluoride – ReF_4 – 262.31 – Dark green – D 5.383^{26} (883) – M.P. 124.5 (883)
Rhenium (VI) fluoride – ReF_6 – 300.31 – Pale yellow – D $3.616^{18.8}$ (883) – M.P. 18.8 (883) – B.P. 47.6 (883)
Rhenium (VI) fluoride oxide – ReF_2O_2 – 256.31 – Colorless – B.P. 156 (883)
Rhenium (VI) fluoride oxide – ReF_4O – 278.31 – Colorless – Triclinic – D $3.717^{39.7}$ (Liquid) (883) – M.P. 39.7 (883) – B.P. 62.7 (883)
Rhenium (IV) oxide – ReO_2 – 218.31 – Black – D 11.4 (70) – D.T. 1000 (70)
Rhenium (VI) oxide – ReO_3 – 234.31 – Pale yellow – D 7.43 (X-ray) (672)
Rhenium (VII) oxide – Re_2O_7 – 484.62 – Yellow – D 8.2^{20} (739) – M.P. 296 (521) – B.P. 362.4 (519)
Rhenium (VIII) oxide – Re_2O_8 – 500.62 – Colorless – Globular – D 8.4 (739) – M.P. 147 (521)
Rhenium (IV) sulfide – ReS_2 – 250.43 – Black – D 7.506^{25} (511)
Rhenium (VII) sulfide – Re_2S_7 – 597.04 – Black – D 4.866^{25} (94)
Rhodium – Rh – 102.91 – Silvery white – Cubic – D 12.44^{20} (15) – M.P. 1966 (14) (1026) – B.P. 4500 (15)
Rhodium (III) fluoride – RhF_3 – 159.91 – Red – Trigonal, hexagonal – D 5.38 (874)
Rhodium (III) oxide – Rh_2O_3 – 253.82 – Grayish black – D 8.20 (X-ray) (1106)
Rhodium (III) sulfide – Rh_2S_3 – 302.00 – Black – D 6.40 (513)
Rhodium (V) sulfide – Rh_2S_5 – 366.12 – Dark gray – D 5.00 (513)
Rubidium – Rb – 85.48 – White – Cubic – D 1.53^{20} (15) – M.P. 39 (14) (1026) – B.P. 700 (15)
Rubidium aluminum fluoride – $3RbF \cdot AlF_3$ – 397.41 – M.P. 985 (469)
Rubidium aluminum silicate – $Rb_2O \cdot Al_2O_3 \cdot 2SiO_2$ – 409.02 – Colorless – Hexagonal – R.I. o 1.530, e 1.526 (256)
Rubidium antimonate, fluo- – $RbF \cdot SbF_5$ – 321.24 – Colorless – Prismatic needles – D 3.955^{20} (613) – M.P. 340 (613) – R.I. o ~ 1.394, e ~ 1.399 (613)
Rubidium beryllium fluoride – $2RbF \cdot BeF_2$ – 255.98 – Colorless – D 3.243^{30} (826)
Rubidium borate, fluo- – $RbF \cdot BF_3$ – 172.30 – Colorless – Rhombic – D 2.820 (1108) – M.P. 590 (105) – D.T. 1000 (600 mm.) (105)
Rubidium carbonate – Rb_2CO_3 – 230.97 – Colorless – M.P. 837 (469)
Rubidium carbonate, bi- – $RbHCO_3$ – 146.50 – Colorless – Rhombic – D.T. 179 (760 mm.) (520)
Rubidium chloride – RbCl – 120.94 – Colorless – Cubic – D 2.8032^{25} (1087) – M.P. 717 (521) – T.P. 20 (1040) – B.P. 1381 (519) – R.I. 1.49374^{25} (1086)
Rubidium chromate – $Rb_2O \cdot CrO_3$ – 286.97 – Yellow – Rhombic – D 3.52 (940) – R.I. p –, m 1.71, g 1.72 (1075)

Rubidium chromate, di- – $Rb_2O \cdot 2CrO_3$ – 386.98 – Triclinic or monoclinic – D 3.1 (828) – R.I. o $>$ 1.95, e 1.70 (976)
Rubidium cyanate, thio- – $RbSCN$ – 143.56 – M.P. 195 (469)
Rubidium fluoride – RbF – 104.48 – Colorless – Cubic – D 3.557 (416) – M.P. 775 (1054) – B.P. 1408 (519) – R.I. 1.396 (1075)
Rubidium fluoride, acid- – $RbF \cdot HF$ – 124.49 – Colorless – M.P. 205 (810)
Rubidium formate – $Rb \cdot HCO_2$ – 130.50 – Colorless – Plates – M.P. 170 (931)
Rubidium hydroxide – $RbOH$ – 102.49 – Colorless – D 3.203^{11} (469) – M.P. 301 (422) – T.P. 245 (422)
Rubidium lithium nitrate – $RbLi(NO_3)_2$ – 216.44 – M.P. 191 (814)
Rubidium magnesium fluoride – $RbF \cdot MgF_2$ – 166.80 – M.P. 881 (831)
Rubidium magnesium fluoride – $2RbF \cdot MgF_2$ – 271.28 – M.P. 784 (831)
Rubidium manganate, per- – $RbMnO_4$ – 204.41 – D 3.235^{10} (469) – D.T. 259 (208)
Rubidium nitrate – $RbNO_3$ – 147.49 – Colorless – Hexagonal – D 3.112^{20} (388) – M.P. 305 (521) – T.P. 160.5, 216, 290 (814) (859) – R.I. p 1.51, m 1.52, g 1.524 (469)
Rubidium nitrate, acid- – $RbNO_3 \cdot HNO_3$ – 210.51 – Colorless – Tetragonal – M.P. 62 (469)
Rubidium nitrate, acid- – $RbNO_3 \cdot 2HNO_3$ – 273.52 – Colorless – M.P. 45 (469)
Rubidium oxalate, acid- – $RbHC_2O_4$ – 174.51 – Colorless – Monoclinic – D 2.549 (411) – R.I. p 1.386, m 1.555, g 1.583 (411)
Rubidium oxide – Rb_2O – 186.96 – Pale yellow – Cubic – D 3.72 (469) – D.T. 400 (469)
Rubidium oxide, per- – Rb_2O_2 – 202.96 – Yellow – Cubic – D 3.65 (469) – M.P. 570 (175) – D.T. 1011 (760 mm.) (175)
Rubidium phosphate, fluo- – $RbF \cdot PF_5$ – 230.46 – Plates – D 3.057^{19} (614)
Rubidium selenate – $Rb_2O \cdot SeO_3$ – 313.92 – Rhombic – D 3.90 (469) – R.I. p 1.5515, m 1.5537, g 1.5582 (469)
Rubidium selenide – Rb_2Se – 249.92 – D.T. 640 (in vacuum) (61)
Rubidium silicate – $Rb_2O \cdot 2SiO_2$ – 307.08 – M.P. 1155 (217)
Rubidium silicate – $Rb_2O \cdot 4SiO_2$ – 427.20 – M.P. 955 (217)
Rubidium silicate, fluo- – $2RbF \cdot SiF_4$ – 313.02 – Hexagonal – D 3.332^{20} (469)
Rubidium sulfate – $Rb_2SO_4(I)$ – 267.02 – Hexagonal – D 2.529^{1100} (469) – M.P. 1074 (478) – B.P. 1710 (648)
Rubidium sulfate – $Rb_2SO_4(II)$ – 267.02 – Colorless – Rhombic – D 3.613 (469) – Transition to I 653 (469) – R.I. p 1.5131, m 1.5133, g 1.5144 (469)
Rubidium sulfate, bi- – $RbHSO_4$ – 182.55 – Colorless – Rhombic – D 2.892^{16} (469) – R.I. p –, m 1.473, g – (1075)
Rubidium sulfide – Rb_2S – 203.02 – Colorless to pale yellow – Cubic – D 2.912 (469)
Rubidium sulfide, di- – Rb_2S_2 – 235.08 – Dark red – M.P. $\sim$ 420 (97)
Rubidium titanium fluoride – $2RbF \cdot TiF_4$ – 228.38 – M.P. 750 (339)
Ruthenium – Ru – 101.7 – Gray – Hexagonal – D 12.2^{20} (15) – M.P. 2500 (14) (1026) – B.P. 4900 (15)
Ruthenium (III) chloride – $RuCl_3$ – 208.07 – Black – Trigonal, hexagonal – D 3.11 (830)
Ruthenium (V) fluoride – RuF_5 – 196.70 – Dark green – D 2.963^{17} (886) – M.P. 101 (886) – B.P. 270 (873)
Ruthenium (IV) oxide – RuO_2 – 133.70 – Deep blue – Tetragonal – D 7.2 (469)
Ruthenium (VIII) oxide – RuO_4 – 165.70 – Yellow and brown – Rhombic – D 3.29^{21} (590) – M.P. 25.5 (469) – B.P. 101 (183 mm.) (469)
Ruthenium (III) sulfide – Ru_2S_3 (Nat. laurite) – 299.58 – Cubic – D 6.99 (469)
Ruthenium (IV) sulfide – RuS_2 – 165.82 – Light gray – Cubic – D 6.145 (514)
Samarium – Sa (or Sm) – 150.43 – D 6.93^{25} (114) – M.P. $>$ 1300 (14) (1026)
Samarium borate – $Sa_2O_3 \cdot B_2O_3$ – 418.50 – D 6.05 (469)
Samarium (II) chloride – $SaCl_2$ – 221.34 – Brownish red – D 4.56 (554)
Samarium chloride – $SaCl_3$ – 256.80 – Faint yellow – Prism – D 4.30^{25} (540) – M.P. 677 (554)
Samarium fluoride – SaF_3 – 207.43 – Hexagonal – D 6.83 (X-ray) (751)
Samarium formate – $Sa(HCO_2)_3$ – 285.48 – D 3.733 (469)
Samarium molybdate – $Sa_2O_3 \cdot 3MoO_3$ – 778.01 – Violet – Tetragonal – D 5.36 (675)
Samarium nitrate, hydrate – $Sa(NO_3)_3 \cdot 6H_2O$ – 444.55 Yellow – Triclinic – D 2.375 (469) – M.P. 78-79 (715)
Samarium oxide – Sa_2O_3 – 348.86 – Yellowish white – Cubic, rhombic, trigonal – D 7.43 (469)
Samarium phosphate – $Sa_2O_3 \cdot P_2O_5$ – 490.90 – D 5.83^{18} (675)
Samarium phosphate – $Sa_2O_3 \cdot 5P_2O_5$ – 1059.06 – D 3.487^{29} (675)
Samarium selenide – Sa_2Se_3 – 537.74 – Gray black – D 7.10 (551)

Samarium silicate – $Sa_2O_3 \cdot SiO_2$ – 408.92 – Hexagonal, monoclinic (341)

Samarium silicate – $Sa_2O_3 \cdot 2SiO_2$ – 468.98 – Monoclinic (341)

Samarium sulfate – $Sa_2(SO_4)_3$ – 589.04 – Yellowish white – D 3.898 (765) – D.T. 989 (719 mm.) (765)

Samarium sulfate, hydrate – $Sa_2(SO_4)_3 \cdot 8H_2O$ – 733.17 – Yellow – Monoclinic – D 2.957^{20} (423) – —$8H_2O$ at 400 (765) – R.I. p 1.5427, m 1.5519, g 1.5629 (469)

Samarium sulfide – Sa_2S_3 – 397.04 – Brownish yellow – D 5.85^{25} (553) – M.P. 1900 (in vacuum) (793)

Scandium – Sc – 45.10 – D 2.5^{20} (15) – M.P. 1200 (14) (1026) – B.P. 2430 (15)

Scandium borate – $Sc_2O_3 \cdot B_2O_3$ – 207.84 – Hexagonal – D 3.451 (X-ray) (352)

Scandium chloride – $ScCl_3$ – 151.47 – Colorless – D 2.39^{25} (545) – M.P. 960 (282) – B.P. 967 (282)

Scandium fluoride – ScF_3 – 102.10 – Colorless – Hexagonal – D 2.52 (745)

Scandium formate – $Sc(HCO_2)_3$ – 180.15 – Colorless – D 1.91 (961) – R.I. p 1.575, m –, g 1.631 (961)

Scandium nitrate – $Sc(NO_3)_3$ – 231.12 – Colorless – D.T. 150 (469)

Scandium nitrate, hydrate – $Sc(NO_3)_3 \cdot 4H_2O$ – 303.19 – Colorless – Prismatic – D.T. 100 (469)

Scandium oxide – Sc_2O_3 – 138.20 – Colorless – D 3.864 (469)

Scandium selenate – $Sc_2O_3 \cdot 3SeO_3$ – 519.08 – Tetragonal – D 3.27 (1018)

Scandium selenide – Sc_2Se_3 – 327.08 – Reddish violet – D $\sim$ 4.52 (551)

Scandium silicate – $Sc_2O_3 \cdot 2SiO_2$ (Nat. thortveitite) – 258.32 – Rhombic – D 3.57 (469) – R.I. p 1.757, m 1.78, g 1.803 (469)

Scandium sulfate – $Sc_2(SO_4)_3$ – 378.38 – Colorless – D 3.579 (469) – D.T. 550 (675)

Scandium sulfide – Sc_2S_3 – 186.38 – Yellow – D 2.90^{25} (552)

Selenium – Se – 78.96 – Dark red or gray – Hexagonal – D 4.81^{20} (15) – M.P. 217.4 (1068) – B.P. 684.8 (925) – R.I. o 3.0, e 3.17 (6800) (469)

Selenium – Se (Glass) – 78.96 – Dark red – D 4.28 (703) – R.I. 2.92 (1075)

Selenium (IV) fluoride – SeF_4 – 154.96 – Colorless liquid – D 2.77 (809) – M.P. —13.2 (809) – B.P. 93 (809)

Selenium (VI) fluoride – SeF_6 – 192.96 – Colorless – D $3.27^{-34.8}$ (Solid) $2.26^{-34.8}$ (Liquid) (549) – M.P. —34.8 (549) – S.P. —45.8 (549)

Selenium (IV) fluoride oxide – SeF_2O – 170.96 – D 2.67 (809) – M.P. 4.6 (809) – B.P. 124 (809)

Selenium (IV) oxide – SeO_2 – 110.96 – Colorless – Tetragonal – D 3.593 (451) – M.P. 340 (469) – S.P. 317 – R.I. o > 1.76, e > o (143)

Selenium (VI) oxide – SeO_3 – 126.96 – Pale yellow – D 3.6 (675) – D.T. 120 (675)

Selenium (IV) oxide, hydrate – $SeO_2 \cdot H_2O$ – 128.98 – Colorless – Hexagonal – D 3.004^{15} (469) – M.P. 70 (Incong.) (472)

Selenium (VI) oxide, hydrate – $SeO_3 \cdot H_2O$ – 144.98 – Colorless – Hexagonal – D 2.950^{15} (469) – M.P. 58 (469)

Selenium (VI) oxide, hydrate – $SeO_3 \cdot 2H_2O$ – 162.99 – Colorless – Needles – D 2.627^{15} (469) – M.P. 25 (469) – B.P. 205 (675)

Silicon – Si – 28.06 – Graphite black – Cubic – D 2.4^{20} (15) – M.P. 1430 (14) (1026) – B.P. 2290 (15)

Silicon carbide – SiC – 40.07 – Colorless – Hexagonal, trigonal – D 3.17 (469) – M.P. $\sim$ 2230 (675) – B.P. 2340 (872) – R.I. o 2.654, e 2.697 (469)

Silicon chloride – $SiCl_4$ – 169.89 – Colorless liquid – D 1.4812^{20} (849) – M.P. —68 (81) – B.P. 57.5 (92) – R.I. 1.412 (469)

Silicon cyanate –$Si(OCN)_4$ – 228.13 – Colorless – D 1.414^{20} (292) – M.P. 34.5 (292) – B.P. 247.2 (292) – R.I. 1.4646 (292)

Silicon cyanate, iso- – $Si(NCO)_4$ – 228.13 – Colorless – D 1.411^{20} (292) – M.P. 26.0 (292) – B.P. 185.6 (292) – R.I. 1.4610 (292)

Silicon cyanate, thio- – $Si(SCN)_4$ – 292.37 – Colorless – M.P. 145 (796) – B.P. 314.2 (469)

Silicon fluoride – SiF_4 – 104.06 – Colorless gas – D 1.66^{-95} (Liquid) 2.133^{-183} (Solid) (632) – M.P. —90.2 (1318 mm.) (771) – S.P. —95.0 (875)

Silicon fluoride – Si_2F_6 – 170.12 – Colorless – M.P. — 18.5 (521) – S.P. — 19.1 (915)

Silicon oxide, mono- – SiO – 44.06 – Bright brown (1123) – Cubic (1123) – D 2.22 (X-ray) (470)

Silicon oxide – SiO_2 (Super low quartz) – 60.06 – Transition to low quartz > —182.4 (754)

Silicon oxide – SiO_2 (Low quartz) – 60.06 – Colorless – Hexagonal – D 2.649^{20} (945) – Transition to high quartz 573 (945) – R.I. o 1.544, e 1.553 (945)

Silicon oxide – SiO_2 (High quartz) – 60.06 – Colorless – Hexagonal – Metastable M.P. 1430 (945) – Transition to tridymite 867 (577) – R.I. o 1.533, e 1.540 (at 580°C.) (841)

Silicon oxide – SiO_2 (Low tridymite) – 60.06 – Colorless – Rhombic – D 2.26° (945) – Transition to lower high-tridymite 117 (945) – R.I. p 1.478, m 1.479, g 1.481 (244)

Silicon oxide – SiO_2 (Lower high-tridymite) – 60.06 – Colorless – Hexagonal – Transition to upper high-tridymite 163 (945)

Silicon oxide – SiO_2 (Upper high-tridymite) – 60.06 – Colorless – Hexagonal – Metastable M.P. 1670 – Transition to high cristobalite 1470 (945)

Silicon oxide – SiO_2 (Low cristobalite) – 60.06 – Colorless – Tetragonal – D 2.32° (945) – Transition to high cristobalite 200-275 (~ 220) (945) (734) – R.I. o 1.487, e 1.484 (469)

Silicon oxide – SiO_2 (High cristobalite) – 60.06 – Colorless – Cubic – M.P. 1713 (1728 on new Int. Temp. Scale) (945) – B.P. 2950 (872) – R.I. 1.466 (366)

Silicon oxide – SiO_2 (Nat. chalcedony) – 60.06 – Fibrous – D 2.55-2.63 (1076) – R.I. o 1.537, e 1.530 (1076)

Silicon oxide – SiO_2 (Nat. lechatelierite) – 60.06 – Vitreous – D 2.19 (1076) – R.I. 1.458 (1076)

Silicon oxide – SiO_2 (Glass) – 60.06 – Colorless – D 2.203° (945) – R.I. 1.4585 (703)

Silicon phosphate – $SiO_2 \cdot P_2O_5$ – 202.02 – Colorless – Cubic – D 3.23 (X-ray) (639)

Silicon sulfide, mono- – SiS – 60.12 – Yellow and black – Needle-like – D 1.853^{18} (675)

Silicon sulfide – SiS_2 – 92.18 – Colorless – Rhombic – D 2.02 (1002) – M.P. 1090 (1002)

Silver – Ag – 107.880 – White – Cubic – D 10.5^{20} (15) – M.P. 960.5 (14) (1026) – B.P. 2152 (278)

Silver antimonate, thio- – $Ag_2S \cdot Sb_2S_3$ (Nat. miargyrite) – 587.52 – Red – Monoclinic – D 5.36 (469) – M.P. 509 (480) – R.I. p –, m $>$ 2.72 (Li line), g – (617)

Silver antimonate, thio- – $3Ag_2S \cdot Sb_2S_3$ (Nat. pyroargyrite) – 1083.16 – Red – Trigonal – D 5.81 (1019) – M.P. 486 (480) – R.I. o 3.084, e 2.881 (All for Li line) (469)

Silver arsenate – $3Ag_2O \cdot As_2O_5$ – 925.10 – Brownish red – Cubic – D 6.657^{25} (469)

Silver arsenite – $3Ag_2O \cdot As_2O_3$ – 893.10 – Yellow – D.T. 150 (469)

Silver arsenite, thio- – $Ag_2S \cdot As_2S_3$ (Nat. trechmannite) – 493.82 – Red – Trigonal – D 4.70 (469) – R.I. o 2.6 (Li-line), e – (469)

Silver arsenite, thio- – $Ag_2S \cdot As_2S_3$ (Nat. smithite) – 493.82 – Red – Monoclinic – D 4.70 (469) – R.I. p 2.48, m 2.58, g 2.60 (469)

Silver arsenite, thio- – $3Ag_2S \cdot As_2S_3$ (Nat. xanthoconite) – 985.82 – Orange yellow – Rhombic – D 5.2 (469) – R.I. p –, m 3, g – (469)

Silver arsenite, thio- – $3Ag_2S \cdot As_2S_3$ (Nat. proustite) – 985.82 – Scarlet – Trigonal – D 5.49 (469) – M.P. 490 (480) – R.I. o 3.088, e 2.792 (469)

Silver carbonate – Ag_2CO_3 – 275.77 – Colorless or yellow – D 6.077 (469) – D.T. 214 (760 mm.) (520)

Silver chloride – AgCl – 143.34 – Colorless – Cubic – D 5.56 (67) – M.P. 455 (521) – B.P. 1564 (519) – R.I. 2.0710 (469)

Silver chromate – $Ag_2O \cdot CrO_3$ – 331.77 – Red or dark green – Monoclinic, acicular or tabular crystals – D 5.625^{25} (469)

Silver chromate, di- – $Ag_2O \cdot 2CrO_3$ – 431.78 – Ruby red – Triclinic – D 4.770^{25} (469)

Silver fluoride – AgF – 126.88 – Yellow – Cubic – D 5.852^{16} (469) – M.P. 435 (469) – B.P. ~ 1150 (873)

Silver fluoride, di- – AgF_2 – 145.88 – Dark brown – Rhombic – D 4.57-4.78 (879) – M.P. 690 (1047) – D.T. 700 ($<$76 mm.) (1047)

Silver fluoride, tri- – AgF_3 – 164.88 – Colorless liquid – M.P. —5.95 (888) – B.P. 57.13 (743 mm.) (888)

Silver manganate, per- – $AgMnO_4$ – 226.81 – Black – Monoclinic – D 4.27^{25} (209)

Silver nitrate – $AgNO_3$ – 169.89 – Colorless – Rhombic – D 4.352^{19} (469) – M.P. 209.01 (631) – T.P. 160 (518) – D.T. 444 (469) – R.I. p 1.729, m 1.744, g 1.788 (1075)

Silver nitrite – $AgNO_2$ – 153.89 – Colorless – Rhombic – D 4.493^{0} (157) – D.T. 105 (157)

Silver oxalate – $Ag_2C_2O_4$ – 303.78 – Colorless – D 5.029^{4} (469) – D.T. 140 (469)

Silver oxide – Ag_2O – 231.76 – Brown – Cubic – D 7.143^{17} (469) – D.T. 300 (469)

Silver oxide, per- – Ag_2O_2 – 247.76 – Gray – Cubic – D 7.44 (469) – D.T. $>$ 100 (469)

Silver phosphate, meta- – $Ag_2O \cdot P_2O_5$ – 373.80 – Colorless – D 6.370 (469) – M.P. 482 (469)

Silver phosphate, pyro- – $2Ag_2O \cdot P_2O_5$ – 605.56 – Colorless – Radiating crystals – D 5.306^{8} (469) – M.P. 585 (469)

Silver phosphate, ortho- – $3Ag_2O \cdot P_2O_5$ – 837.32 – Yellow – Cubic – D 6.370^{25} (469) – M.P. 849 (469)

Silver phosphate, hydrate – $Ag_2O \cdot P_2O_5 \cdot H_2O$ – 391.82 – Colorless – M.P. 235 (675) – D.T. 240 (675)

Silver phosphate, hydrate – $2Ag_2O \cdot P_2O_5 \cdot H_2O$ – 623.58 – Colorless – Hexagonal – D.T. 110 (469) – R.I. o 1.8036, e 1.7983 (469)

Silver rhenate – $Ag_2O \cdot Re_2O_7$ – 716.38 – Light yellow – D 7.05^{25} (444) – M.P. 430 (1036) – D.T. 455 (1036)

Silver selenide – Ag_2Se (Naumannite) – 294.72 – Black – Cubic – D 8.200 (443) – M.P. 880 (469) – T.P. 133 (518)

Silver selenite – $Ag_2O \cdot SeO_2$ – 342.72 – Colorless – Needles – D 5.929 (469)

Silver silicate, thio- – $3Ag_2S \cdot 2SiS_2$ – 927.82 – D 4.998^{25} (697) – M.P. 758 (697)

Silver silicate, thio- – $4Ag_2S \cdot SiS_2$ – 1083.46 – D 6.550 (697) – M.P. 958 (697)

Silver sulfate – Ag_2SO_4 – 311.82 – Grayish white – Rhombic – D 5.433 (1089) – M.P. 657 (521) – T.P. 411 (609) – R.I. o 1.7583, m 1.7748, g 1.7852 (1089)

Silver sulfide – Ag_2S(I) – 247.82 – Cubic – D 7.317 (469) – M.P. 842 (522)

Silver sulfide – Ag_2S(II) – 247.82 – Gray – Rhombic – D 7.20^{25} (445) – Transition to I 175 (523)

Silver telluride – Ag_2Te (Hessite) – 243.37 – Gray – Cubic, rhombic – D 8.49 (441) – M.P. 959 – T.P. 145 (582)

Silver telluride – Ag_3Te_2 – 478.86 – M.P. 465 (Incong.) – T.P. 286 and 425 (582)

Silver vanadate, pyro- – $2Ag_2O \cdot V_2O_5$ – 645.42 – Pale yellow – M.P. 383 (469)

Sodium – Na – 22.997 – Silvery white – Cubic – D 0.97^{20} (15) – M.P. 97.7 (14) (1026) – B.P. 892.2 (15)

Sodium aluminate – $Na_2O \cdot Al_2O_3$ – 163.94 – Colorless – M.P. > 1700 (515) – R.I. p 1.566, m 1.575, g 1.580 (145)

Sodium aluminate – $Na_2O \cdot 12Al_2O_3$ (Miscalled "beta-alumina") (838) – 1285.28 – Colorless – Hexagonal – D 3.249 (838) – D.T. 1300 (in vac.) (316) – R.I. o 1.668, e 1.630 (838)

Sodium aluminum antimonate – $Na_2O \cdot 2Al_2O_3 \cdot Sb_2O_5$ (Nat. swedenborgite) – 589.39 – Colorless – Hexagonal – D 4.29 (617) – R.I. o 1.772, e 1.770 (17)

Sodium aluminum fluoride – $2NaF \cdot AlF_3$ (Nat. chodnewite) – 167.97 – Tetragonal – D 3.0 (469) – R.I. o 1.349, e 1.342 (469)

Sodium aluminum fluoride – $3NaF \cdot AlF_3$ (Cryolite) – 209.97 – Colorless – Monoclinic – D 2.9482^{18} (862) – M.P. 1000 (521) – R.I. p 1.339, m 1.340, g 1.340 (592)

Sodium aluminum fluoride – $3NaF \cdot 2AlF_3$ – 293.94 – M.P. 740 (813)

Sodium aluminum fluoride – $5NaF \cdot 3AlF_3$ (Chiolite) – 461.91 – Tetragonal – D 3.005 (190) – M.P. 725 (Incong.) (271)

Sodium aluminum hydroxycarbonate – $NaAl(OH)_2CO_3$ (Nat. dawsonite) – 144.00 – Rhombic – D 2.4 (469) – R.I. p 1.466, m 1.542, g 1.596 (469)

Sodium aluminum phosphate – $Na_2O \cdot Al_2O_3 \cdot 2P_2O_5$ – 448.02 – Colorless – Monoclinic – D 2.7 (756)

Sodium aluminum phosphate – $3Na_2O \cdot 2Al_2O_3 \cdot 3P_2O_5$ – 815.99 – Colorless – D 2.1 (756)

Sodium aluminum silicate – $Na_2O \cdot Al_2O_3 \cdot 2SiO_2$(I) (Carnegieite) – 284.05 – Triclinic – D 2.57 (469) – M.P. 1526 (469) – R.I. p 1.509, m –, g 1.514 (123)

Sodium aluminum silicate – $Na_2O \cdot Al_2O_3 \cdot 2SiO_2$(II) (Nephelite) – 284.05 – Colorless – Hexagonal – D 2.619^{21} (120) – Transition to I 1249-1259 (367) – R.I. o 1.537, e 1.533 (120)

Sodium aluminum silicate – $Na_2O \cdot Al_2O_3 \cdot 2SiO_2$ (Glass) – 284.05 – Colorless – R.I. 1.515 (1004)

Sodium aluminum silicate – $Na_2O \cdot Al_2O_3 \cdot 3SiO_2$ (Nat. metanatrolite) – 344.11 – Colorless – Monoclinic – R.I. p 1.483, m 1.485, g 1.494 (426)

Sodium aluminum silicate – $Na_2O \cdot Al_2O_3 \cdot 4SiO_2$ (Nat. jadeite) – 404.17 – Monoclinic – D 3.34 (469) – M.P. 1050 (469) – R.I. p –, m 1.654, g – (469)

Sodium aluminum silicate – $Na_2O \cdot Al_2O_3 \cdot 4SiO_2$ (Glass) – 404.17 – Colorless – D 2.43 (960)

Sodium aluminum silicate – $Na_2O \cdot Al_2O_3 \cdot 6SiO_2$ (Albite) – 524.29 – Colorless – Triclinic – D 2.61 (469) – M.P. 1118 (367) (682) – T.P. 900 (367) (682) – R.I. p 1.525, m 1.529, g 1.536 (469)

Sodium aluminum silicate – $Na_2O \cdot Al_2O_3 \cdot 6SiO_2$ (Glass) – 524.29 – Colorless – D 2.382 (221) – R.I. 1.4892 (615)

Sodium aluminum silicate chloride – $3Na_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2NaCl$ (Nat. sodalite) – 969.05 – Colorless – Cubic – D $2.295^{14.5}$ (134) – R.I. 1.484 (134)

Sodium aluminum silicate chloride – $3Na_2O \cdot 3Al_2O_3 \cdot 54SiO_2 \cdot 2NaCl$ (Nat. marialite) – 3851.93 – Colorless – Tetragonal – D 2.56 (469) – R.I. o 1.539, e 1.537 (469)

Sodium aluminum silicate fluoride – $Na_2O \cdot Al_2O_3 \cdot 9SiO_2 \cdot 2NaF$ (Nat. leifite) – 788.47 – Hexagonal – D 2.57 (469) – R.I. o 1.518, e 1.522 (469)

Sodium aluminum silicate, hydrate – $Na_2O \cdot Al_2O_3 \cdot 3SiO_2 \cdot 2H_2O$ (Nat. natrolite) – 380.14 – Colorless – Rhombic and monoclinic – D 2.25 (469) – R.I. p 1.480, m 1.482, g 1.493 (469)

Sodium aluminum silicate, hydrate – $Na_2O \cdot Al_2O_3 \cdot 4SiO_2 \cdot 2H_2O$ (Analcite) – 440.20 – Colorless – Cubic – D 2.25 (469) – R.I. 1.472 (715)

Sodium aluminum silicate, hydrate – $Na_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$ (Nat. paragonite) – 764.20 – Colorless – Monoclinic – D 2.8 (469) – R.I. p –, m 1.60, g – (469)

Sodium aluminum silicate, hydrate – $2Na_2O \cdot Al_2O_3 \cdot 6SiO_2 \cdot H_2O$ (Nat. ussingite) – 604.30 Colorless – Triclinic – D 2.50 (469) – R.I. p 1.504, m 1.508, g 1.545 (469)

Sodium aluminum silicate, hydrate – $2Na_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 7H_2O$ (Nat. hydronephelite) – 916.28 – Colorless – Hexagonal – D 2.3 (469) – R.I. o 1.490, e 1.502 (469)

Sodium aluminum silicate, hydrate – $3Na_2O \cdot 2Al_2O_3 \cdot 8SiO_2 \cdot H_2O$ (Nat. nanjakasite) – 888.35 – Colorless – Monoclinic – D 2.615 (106) – R.I. p –, m 1.537, g – (106)

Sodium antimony fluoride – $NaF \cdot SbF_5$ – 258.76 – Rhombohedron – D 3.379^{18} (613) – R.I. $<$ 1.360 (613)

Sodium arsenate, meta- – $Na_2O \cdot As_2O_5$ – 291.82 – Rhombic – D 2.301 (828) – M.P. 615 (12)

Sodium arsenate, pyro- – $2Na_2O \cdot As_2O_5$ – 353.81 – D 2.21 (429) – M.P. 850 (12) – T.P. 688 (12)

Sodium arsenate, ortho- – $3Na_2O \cdot As_2O_5$ – 415.80 – D 2.835 (469) – M.P. 1260 (12) – T.P. 410 (12)

Sodium arsenate, hydrate – $Na_2O \cdot As_2O_5 \cdot 4H_2O$(I) – 363.88 – Colorless – Monoclinic – — H_2O at 70, — $2H_2O$ at 104.3 (329)

Sodium arsenate, hydrate – $Na_2O \cdot As_2O_5 \cdot 4H_2O$(II) – 363.88 – Rhombic – D 2.535 (469) – Transition to I at 53.5 (329) – R.I. p 1.538, m 1.554, g 1.561 (469)

Sodium arsenate, hydrate – $Na_2O \cdot As_2O_5 \cdot 6H_2O$ – 381.90 – Rhombic – D 2.309 (469) – — $2H_2O$ at 17.3 (329) – R.I. p 1.479, m 1.502, g 1.527 (469)

Sodium arsenate, hydrate – $Na_2O \cdot As_2O_5 \cdot 10H_2O$ – 471.98 – D 2.32 (505) – R.I. p 1.479, m 1.502, g 1.527 (505)

Sodium arsenate, hydrate – $2Na_2O \cdot As_2O_5 \cdot 15H_2O$ – 624.05 – Monoclinic – D 1.87 (469) – R.I. p 1.462, m 1.466, g 1.478 (469)

Sodium arsenate, hydrate – $2Na_2O \cdot As_2O_5 \cdot 25H_2O$ – 804.21 – Monoclinic – D 1.72 (469) – M.P. 28 (469) – R.I. p 1.445, m 1.450, g 1.451 (469)

Sodium arsenate, hydrate – $3Na_2O \cdot As_2O_5 \cdot 24H_2O$ – 848.18 – Trigonal – D 1.759 (469) – M.P. 86.3 (469) – R.I. o 1.457, e 1.466 (469)

Sodium barium carbonate – $Na_2CO_3 \cdot BaCO_3$ – 303.37 – M.P. 740 (469)

Sodium barium phosphate – $Na_2O \cdot 2BaO \cdot P_2O_5$(I) – 510.75 – Colorless – Tetragonal – D 6.43 (X-ray) (544) (972)

Sodium barium titanium silicate – $2Na_2O \cdot BaO \cdot 2TiO_2 \cdot 10SiO_2$ (Nat. leucosphenite) – 975.75 – Monoclinic – D 3.1 (469) – R.I. p 1.645, m 1.661, g 1.688 (469)

Sodium beryllium antimonate – $Na_2O \cdot 8BeO \cdot Sb_2O_5$ (Nat. swedenborgite) – 585.67 – Colorless – Cubic – D 6.98 (X-ray) (775) (972)

Sodium beryllium antimonate – $Na_2O \cdot 8BeO \cdot Sb_2O_5$ (Nat. swedenborgite) – 585.67 – Colorless – Hexagonal – D 6.46 (X-ray) (972) (775)

Sodium beryllium fluoride – $NaF \cdot BeF_2$ – 89.02 – Colorless – M.P. 520 (348)

Sodium beryllium fluoride – $2NaF \cdot BeF_2$ – 131.02 – Colorless – Rhombic, monoclinic – D 2.471^{20} (748) – M.P. 575 (748) – R.I. $\sim$ 1.2 (748)

Sodium beryllium phosphate – $Na_2O \cdot 2BeO \cdot P_2O_5$ (Nat. beryllonite) – 254.07 – Rhombic – D 2.85 (469) – R.I. p 1.552, m 1.558, g 1.561 (469)

Sodium beryllium silicate – $Na_2O \cdot BeO \cdot 2SiO_2$ (Nat. chkalovite) – 207.13 – Colorless – Rhombic – D 2.662 (331) – R.I. p 1.544, m –, g 1.549 (331)

Sodium beryllium silicate – $Na_2O \cdot BeO \cdot 4SiO_2$ (Glass) – 327.25 – Colorless – D 2.450 (605) – R.I. 1.5096 (605)

Sodium beryllium silicate – $3Na_2O \cdot 6BeO \cdot 14SiO_2$ – 1176.93 – Rhombic – D 2.552 (320) – R.I. p –, m 1.532-1.545, g – (320)

Sodium beryllium silicate, hydrate – $Na_2O \cdot 2BeO \cdot 6SiO_2 \cdot H_2O$ (Nat. eudidymite) – 490.41 – Monoclinic – D 2.55 (469) – R.I. p 1.545, m 1.546, g 1.551 (469)

Sodium beryllium silicate, hydrate – $Na_2O \cdot 2BeO \cdot 6SiO_2 \cdot H_2O$ (Nat. epididymite) – 490.41 – Rhombic – D 2.55 (469) – R.I. p 1.565, m 1.569, g 1.569 (469)

Sodium borate – $Na_2O \cdot B_2O_3$ – 131.64 – Colorless – Hexagonal – D 2.464 (268) – M.P. 966 (709) – B.P. 1434 (203) – R.I. o 1.568, o 1.457 (709)

Sodium borate – $Na_2O \cdot 2B_2O_3$(I) – 201.27 – Colorless – M.P. 742 (709) – B.P. 1575 (203) – R.I. p 1.471, m 1.493, g 1.528 (709)

Sodium borate – $Na_2O \cdot 2B_2O_3$(II) – 201.27 – Colorless – Transition to I at 600 (709) – R.I. p 1.50, m 1.523, g 1.555 (709)

Sodium borate – $Na_2O \cdot 2B_2O_3$(III) – 201.27 – Colorless – Rhombic – D 2.279^{25} (495) – Transition to I 725 (709) – R.I. p 1.526, m 1.544, g 1.575 (709)

Sodium borate – $Na_2O \cdot 2B_2O_3$ (Glass) – 201.27 – Colorless – D 2.361^{25} (495) – R.I. 1.516 (703)

Sodium borate – $Na_2O \cdot 3B_2O_3$ – 270.91 – Colorless – Triclinic – M.P. 766 (Incong.) (709) – R.I. p 1.453, m 1.525, g 1.551 (709)

Sodium borate – $Na_2O \cdot 4B_2O_3$ – 340.55 – Colorless – Triclinic – M.P. 816 (709) – R.I. p 1.499, m 1.525, g 1.582 (709)

Sodium borate – $Na_2O \cdot 4B_2O_3$ (Glass) – 340.55 – Colorless – R.I. 1.501 (703)

Sodium borate – $2Na_2O \cdot B_2O_3$ – 193.62 – Colorless – M.P. 625 (709) – R.I. p 1.50, m 1.52, g 1.550 (709)

Sodium borate, hydrate – $Na_2O \cdot B_2O_3 \cdot 8H_2O$ – 275.76 – Colorless – Monoclinic – D 2.09 (202) – M.P. 53.5 (Incong.) (202) – — $8H_2O$ at 100-140 (202) – R.I. p 1.443, m 1.467, g 1.481 (202)

Sodium borate, hydrate – $Na_2O \cdot 2B_2O_3 \cdot 4H_2O$ (Kernite) – 273.33 – Colorless – Monoclinic – D 1.91^{20} (678) – M.P. 151.5 (678) – R.I. p 1.454, m 1.472, g 1.488 (894)

Sodium borate, hydrate – $Na_2O \cdot 2B_2O_3 \cdot 5H_2O$ (Tincalconite) – 291.36 – Colorless - Trigonal – D 1.880 (896) – Transition to $Na_2O \cdot 2B_2O_3 \cdot 4H_2O$ at 39 (678) Transition to $Na_2O \cdot 2B_2O_3 \cdot 2H_2O$ at 88 (679) Transition to $Na_2O \cdot 2B_2O_3 \cdot H_2O$ at 190 (679) – R.I. o 1.461, e 1.474 (896)

Sodium borate, hydrate – $Na_2O \cdot 2B_2O_3 \cdot 10H_2O$ (Borax) – 381.44 – Colorless – Monoclinic – D 1.73 (469) – Transition to $Na_2O \cdot 2B_2O_3 \cdot 4H_2O$ at 58.5, Transition to $Na_2O \cdot 2B_2O_3 \cdot 5H_2O$ at 60.8 – — $10H_2O > 400$ (679) – R.I. p 1.447, m 1.469, g 1.472 (469)

Sodium borate, hydrate – $Na_2O \cdot 5B_2O_3 \cdot 10H_2O$ – 590.35 – Colorless – Prism – Transition to $Na_2O \cdot 5B_2O_3 \cdot 2H_2O$ at 100 (854)

Sodium borate, fluo- – $NaF \cdot BF_3$ (Ferrucite) – 109.82 – Colorless – Rhombic and cubic – Transition at 241 (1037) – R.I. p 1.301, m 1.301, g 1.307 (612)

Sodium bromide – NaBr – 102.91 – Colorless – Cubic – D 3.213^{25} (1089) – M.P. 747 (521) – B.P. 1392 (519) – R.I. 1.6439 (1089)

Sodium calcium aluminate – $Na_2O \cdot 8CaO \cdot 3Al_2O_3$ – 816.45 – Hexagonal – M.P. 1508 (Incong.) (145) – R.I. p 1.702, m –, g 1.710 (145)

Sodium calcium aluminate – $2Na_2O \cdot 3CaO \cdot 5Al_2O_3$ – 801.92 – Hexagonal – M.P. > 1630 (145) – R.I. Mean 1.592 (145)

Sodium calcium aluminate, hydrate – $Na_2O \cdot CaO \cdot 2Al_2O_3 \cdot 7H_2O$ (Nat. gonnardite) – 448.06 – Rhombic – D 2.26 (617) – R.I. p –, m 1.508, g – (617)

Sodium calcium aluminum phosphate, hydrate – $Na_2O \cdot 2CaO \cdot 6Al_2O_3 \cdot 4P_2O_5 \cdot 17H_2O$ – 1660.22 – Colorless – Monoclinic – D 2.83 (621) – R.I. p 1.584, m 1.598, g 1.602 (621)

Sodium calcium aluminum phosphate, hydrate – $2Na_2O \cdot CaO \cdot 6Al_2O_3 \cdot 4P_2O_5 \cdot 17H_2O$ (Nat. wardite) – 1722.21 – Colorless – Tetragonal – D 2.81 (617) – R.I. o 1.590, e 1.599 (617)

Sodium calcium aluminum silicate – $Na_2O \cdot CaO \cdot Al_2O_3 \cdot 2SiO_2$ (Glass) – 340.13 – Colorless – D 2.658 (890) – R.I. 1.5585 (890)

Sodium calcium aluminum silicate – $Na_2O \cdot CaO \cdot Al_2O_3 \cdot 3SiO_2$ (Glass) – 400.19 – Colorless – D 2.612 (890) – R.I. 1.5450 (890)

Sodium calcium aluminum silicate – $Na_2O \cdot CaO \cdot Al_2O_3 \cdot 4SiO_2$ (Glass) – 460.25 – Colorless – D 2.570 (890) – R.I. 1.5355 (890)

Sodium calcium aluminum silicate – $3Na_2O \cdot 27CaO \cdot 10Al_2O_3 \cdot 28SiO_2$ (Sarkolith) – 4401.21 – Tetragonal – R.I. o 1.631, e 1.615 (149)

Sodium calcium aluminum silicate, hydrate – $Na_2O \cdot CaO \cdot 2Al_2O_3 \cdot 10SiO_2 \cdot 20H_2O$ (Nat. faujasite) – 1282.87 – Cubic – D 1.92 (469) – R.I. 1.48 (469)

Sodium calcium aluminum silicate, hydrate – $Na_2O \cdot 2CaO \cdot 3Al_2O_3 \cdot 9SiO_2 \cdot 8H_2O$ (Nat. pseudonesolite) – 1164.64 – Colorless – Triclinic – D 2.22 (469) – R.I. p –, m 1.510, g – (617)

Sodium calcium aluminum silicate, hydrate – $Na_2O \cdot 2CaO \cdot 3Al_2O_3 \cdot 9SiO_2 \cdot 8H_2O$ (Nat. mesolite) – 1164.64 – Colorless – Monoclinic – D 2.256 (427) – R.I. p 1.505, m 1.505, g 1.506 (469)

Sodium calcium borate, hydrate – $Na_2O \cdot 2CaO \cdot 5B_2O_3 \cdot 10H_2O$ (Nat. probertite) – 702.51 – Colorless – Monoclinic – D 2.141 (617) – R.I. p 1.517, m 1.525, g 1.544 (617)

Sodium calcium borate, hydrate – $Na_2O \cdot 2CaO \cdot 5B_2O_3 \cdot 16H_2O$ (Nat. ulexite) – 810.61 – Colorless – Monoclinic – D 1.65 (617) – R.I. p 1.491, m 1.504, g 1.520 (617)

Sodium calcium carbonate – $Na_2CO_3 \cdot CaCO_3$ – 206.09 – Colorless – Hexagonal – D 2.540 (255) – M.P. 812 (760 mm.) (255) – R.I. o 1.547, e 1.504 (255)

Sodium calcium carbonate – $Na_2CO_3 \cdot 2CaCO_3$ (Nat. shortite) – 306.18 – Rhombic – D 2.629^{25} (267) – M.P. 600 (Incong.) (267) – T.P. 200 (267) – R.I. p 1.531, m 1.555, g 1.570 (267)

Sodium calcium carbonate, hydrate – $Na_2CO_3 \cdot CaCO_3 \cdot 2H_2O$ (Nat. pirssonite) – 224.12 – Rhombic – D 2.35 (469) – M.P. 813 (469) – R.I. p 1.504, m 1.509, g 1.575 (469)

Sodium calcium carbonate, hydrate – $Na_2CO_3 \cdot CaCO_3 \cdot 5H_2O$ (Nat. gaylussite) – 314.20 – Colorless – Monoclinic – D 1.99 (752) – R.I. p 1.444, m 1.516, g 1.523 (469)

Sodium calcium carbonate phosphate – $Na_2CO_3 \cdot CaCO_3 \cdot Ca_3(PO_4)_2$ (Carbonate-apatite) – 516.37 – Colorless – Hexagonal – R.I. o 1.635, e 1.626 (251)

Sodium calcium magnesium aluminum silicate – $Na_2O \cdot 2CaO \cdot 2MgO \cdot Al_2O_3 \cdot 8SiO_2$ (Nat. tuxtlite) – 837.21 – Monoclinic – D 3.27 (469) – R.I. p 1.666, m 1.674, g 1.688 (469)

Sodium calcium phosphate – $Na_2O \cdot 2CaO \cdot P_2O_5$(I) – 316.19 – Colorless – Hexagonal – D 2.17 (X-ray) (544) (972)

Sodium calcium phosphate – $Na_2O \cdot 2CaO \cdot P_2O_5$(II) – 316.19 – Colorless – Rhombic – D 2.90 (X-ray) (544) (972)

Sodium calcium phosphate – $Na_2O \cdot 3CaO \cdot P_2O_5$ – 372.27 – Colorless – Hexagonal – R.I. o 1.623, e 1.62 (612)

Sodium calcium phosphate – $3Na_2O \cdot 3CaO \cdot 2P_2O_5$ – 638.29 – Monoclinic – D 2.1 (469)

Sodium calcium silicate – $Na_2O \cdot CaO \cdot SiO_2$ – 178.13 – Colorless – Cubic – D 2.79 (1093) – R.I. 1.60 (1075)

Sodium calcium silicate – $Na_2O \cdot CaO \cdot 3SiO_2$ (Glass) – 298.25 – Colorless – D 2.639 (890) – R.I. 1.5493 (890)

Sodium calcium silicate – $Na_2O \cdot CaO \cdot 4SiO_2$ (Glass) – 358.31 – Colorless – D 2.579 (890) – R.I. 1.5363 (890)

Sodium calcium silicate – $Na_2O \cdot CaO \cdot 5SiO_2$ (Glass) – 418.37 – Colorless – D 2.530 (890) – R.I. 1.5264 (890)

Sodium calcium silicate – $Na_2O \cdot CaO \cdot 6SiO_2$ (Glass) – 478.43 – Colorless – D 2.490 (407) – R.I. 1.5188 (890)

Sodium calcium silicate – $Na_2O \cdot 2CaO \cdot 3SiO_2$ – 354.33 – Colorless – Pseudocubic – M.P. 1284 (469) – R.I. p 1.595, m –, g 1.598 (705)

Sodium calcium silicate – $Na_2O \cdot 3CaO \cdot 6SiO_2$ – 590.59 – Colorless – Rhombic – M.P. 1047 (Incong.) (469) – R.I. p 1.564, m 1.570, g 1.579 (705)

Sodium calcium silicate – $Na_2O \cdot 3CaO \cdot 6SiO_2$ (Glass) – 590.59 – Colorless – D 2.702 (703) – R.I. 1.571 (703)

Sodium calcium silicate – $2Na_2O \cdot CaO \cdot 3SiO_2$ – 360.24 – Colorless – Cubic – D 2.775 (1093) – M.P. 1141 (Incong.) (469) – R.I. 1.571 (705)

Sodium calcium silicate, hydrate – $Na_2O \cdot 4CaO \cdot 6SiO_2 \cdot H_2O$ (Pectolite) – 664.69 – Monoclinic – D 2.73 (469) – R.I. p 1.595, m –, g 1.648 (561)

Sodium calcium sulfate – $Na_2SO_4 \cdot CaSO_4$ (Nat. glauberite) – 278.20 – Colorless – Monoclinic – D 2.83 (469) – R.I. p 1.515, m 1.532, g 1.536 (469)

Sodium carbonate – Na_2CO_3 – 106.00 – Four modifications (658) – M.P. 854 (521) – T.P. 356, 486, 618 (658) – R.I. p 1.410, m 1.537, g 1.544 (1041)

Sodium carbonate, bi- – $NaHCO_3$ (Nahcolite) – 84.02 – Colorless – Monoclinic – D 2.22 (617) – D.T. 113.4 (760 mm.) (520) – R.I. p 1.380, m 1.500, g 1.586 (617)

Sodium carbonate, hydrate – $Na_2CO_3 \cdot H_2O$ (Thermonatrite) – 124.02 – Rhombic – D 2.255 (757) (199) – M.P. 112.5 (Incong.) (760 mm.) (1041) – R.I. p 1.420, m 1.506, g 1.524 (617)

Sodium carbonate, hydrate – $Na_2CO_3 \cdot 7H_2O$ – 232.12 – Rhombic and trigonal – D 1.51 (469) – D.T. 35.1 (469)

Sodium carbonate, hydrate – $Na_2CO_3 \cdot 10H_2O$ (Natrite) – 286.17 – Rhombic – D 1.446^{17} (228) – Transition to $Na_2CO_3 \cdot 7H_2O$ at 31.85 (1027) – R.I. p 1.405, m 1.425, g 1.440 (469)

Sodium carbonate, hydrate – $2Na_2CO_3 \cdot 5H_2O$ – 402.08 – Colorless – Rhombic – D 2.053 (757) – R.I. p 1.435, m 1.492, g 1.547 (757)

Sodium carbonate, hydrate – $Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$ (Trona) – 226.05 – Colorless – Monoclinic – D 2.13 (617) – M.P. 195 (Incong.) (1042) – R.I. p 1.412, m 1.492, g 1.540 (617)

Sodium carbonate, hydrate – $Na_2CO_3 \cdot 3NaHCO_3$ – 358.06 – Colorless – Needle – R.I. p 1.435, m –, g 1.526 (193)

Sodium carbonate sulfate – $Na_2CO_3 \cdot 2Na_2SO_4$ (Burkeite) – 390.10 – Colorless – Rhombic – D 2.57 (297) – R.I. p 1.450, m 1.490, g 1.492 (297)

Sodium chlorate – $NaClO_3$ – 106.45 – Colorless – Cubic – D 2.49 (469) – M.P. 255 (521) – R.I. 1.5151 (469)

Sodium chlorate, per- – $NaClO_4$ – 122.45 – Colorless – Rhombic – D 2.499 (1086) – M.P. 482 (469) – R.I. p 1.4606, m 1.4617, g 1.4730 (1086)

Sodium chloride – $NaCl$ – 58.45 – Colorless – Cubic – D 2.163 (469) – M.P. 800.4 (845) – B.P. 1465 (519) – R.I. 1.5442 (469)

Sodium chromate – $Na_2O\cdot CrO_3$ – 162.00 – Yellow – Rhombic – D 2.73 (692) – M.P. 392 (469)

Sodium chromate, di- – $Na_2O\cdot 2CrO_3$ – 262.02 – Orange – M.P. 356.7 (635)

Sodium chromium (III) phosphate – $Na_2O\cdot Cr_2O_3\cdot 2P_2O_5$ – 498.09 – Green – Rhombic – D 3.0 (469)

Sodium columbate – $Na_2O\cdot Cb_2O_5$ – 327.81 – Cubic – D 4.609 (X-ray) (815)

Sodium columbate – $3Na_2O\cdot Cb_2O_5$ – 451.79 – D 3.725^{22} (970)

Sodium cyanate, seleno- – $NaCNSe$ – 127.98 – Colorless – Plates – D 2.490^{20} (467)

Sodium cyanate, thio- – $NaCNS$ – 81.08 – Colorless – Rhombic – D 1.73^{20} (467) – M.P. 323 (521) – R.I. p 1.545, m 1.625, g 1.695 (1075)

Sodium cyanide – $NaCN$ – 49.02 – Colorless – Cubic – D 1.596^{20} (99) – M.P. 562 (521) – B.P. 1497 (519) – R.I. 1.452 (803)

Sodium ferrate – See Sodium iron (III) oxide

Sodium fluoride – NaF – 42.00 – Colorless – Cubic – D 2.79 (469) – M.P. 992 (521) – B.P. 1704 (519) – R.I. 1.3258 (954)

Sodium formate – $NaHCO_2$ – 68.02 – Colorless – Monoclinic – D 1.92 (469) – M.P. 255 (526)

Sodium germanate – $Na_2O\cdot GeO_2$ – 166.59 – Colorless – Monoclinic – D 3.31^{22} (917) – M.P. 1083 (919) – R.I. p –, m 1.59, g – (917)

Sodium germanate – $Na_2O\cdot 2GeO_2$ – 271.19 – M.P. 799 (919)

Sodium germanate – $Na_2O\cdot 4GeO_2$ – 480.39 – M.P. 1052 (919)

Sodium hydroxide – $NaOH$ – 40.01 – Colorless – Rhombic – D 2.02 (557) – M.P. 322 (521) – B.P. 1378 (519) – R.I. p 1.457, m 1.470, g 1.472 (706)

Sodium hydroxide, hydrate – $NaOH\cdot H_2O$ – 58.03 – Colorless – Rhombic – D 1.829 (609) – M.P. 65.0 (706) – R.I. p 1.435, m 1.470, g 1.475 (706)

Sodium iodide – NaI – 149.92 – Colorless – Cubic – D 3.667 (469) – M.P. 662 (521) – B.P. 1304 (519) – R.I. 1.7745 (1075)

Sodium iron (III) fluoride – $3NaF\cdot FeF_3$ – 238.85 – Colorless – Cubic – D 2.00 (694)

Sodium iron (III) oxide – $Na_2O\cdot Fe_2O_3$ – 221.67 – Brown – Hexagonal – D 4.23 (353) – M.P. 1345 (560)

Sodium iron (II, III) silicate – $Na_2O\cdot FeO\cdot Fe_2O_3\cdot 5SiO_2$ (Nat. riebeckite) – 593.82 – Monoclinic – D 3.44 (469) – R.I. p –, m 1.687, g – (469)

Sodium iron (II, III) silicate – $Na_2O\cdot 2FeO\cdot Fe_2O_3\cdot 6SiO_2$ (Nat. crocidolite) – 725.73 – Monoclinic – D 3.2 (469) – R.I. p –, m 1.70, g – (469)

Sodium iron (III) silicate – $Na_2O\cdot Fe_2O_3\cdot 4SiO_2$ (Acmite) – 461.91 – Faint yellow – Monoclinic – D 3.5 (469) – M.P. 990 (Incong.) (126) – R.I. p 1.776, m 1.819, g 1.836 (1058)

Sodium iron (III) silicate – $5Na_2O\cdot Fe_2O_3\cdot 8SiO_2$ – 950.11 – Brown – Hexagonal – M.P. 838 (131) – R.I. o 1.609, e 1.625 (131)

Sodium iron (III) silicate – $5Na_2O\cdot Fe_2O_3\cdot 8SiO_2$ (Glass) – 950.11 – Brown – R.I. 1.583 (131)

Sodium iron (III) silicate – $6Na_2O\cdot 4Fe_2O_3\cdot 5SiO_2$ – 1310.96 – M.P. 1091 (131) – R.I. p –, m 1.96, g – (131)

Sodium lanthanum silicate – $Na_2O\cdot La_2O_3\cdot 2SiO_2$ – 507.95 – Colorless – Hexagonal – D 3.92 (1015) – M.P. 1020 (1015) – R.I. o 1.867, e 1.840 (256)

Sodium lead (II) silicate – $Na_2O\cdot 2PbO\cdot 3SiO_2$ – 688.59 – Monoclinic – M.P. 615 (585)

Sodium lead (II) silicate – $Na_2O\cdot 2PbO\cdot 4SiO_2$ – 748.15 – Rhombic – M.P. 635 (Incong.) (585) – R.I. p 1.744, m –, g 1.782 (585)

Sodium lead (II) silicate – $Na_2O\cdot 3PbO\cdot 6SiO_2$(I) – 1091.48 – Tetragonal – M.P. 717 (585) – R.I. p 1.704, m –, g 1.707 (585)

Sodium lead (II) silicate – $Na_2O\cdot 3PbO\cdot 6SiO_2$(II) – 1091.48 – Rhombic – Transition to I 540 (585) – R.I. p 1.719, m –, g 1.744 (585)

Sodium lead (II) silicate – $Na_2O\cdot 3PbO\cdot 7SiO_2$ – 1151.54 – Hexagonal – M.P. 725 (Incong.) (585) – R.I. p 1.726, m –, g 1.750 (585)

Sodium lead (II) silicate – $3Na_2O\cdot 3PbO\cdot 11SiO_2$ – 1516.26 – M.P. 645 (Incong.) (585) – R.I. p 1.617, m –, g 1.681 (585)

Sodium lithium aluminum fluoride – $3NaF\cdot 3LiF\cdot 2AlF_3$ (Nat. cryolithionite) – 371.76 – Cubic – D 2.78 (469) – R.I. 1.339 (469)

Sodium lithium carbonate – $NaLiCO_3$ – 89.947 – Hexagonal – D 2.294 (255) – M.P. 514 (255) – R.I. o 1.538, e 1.406 (255)

Sodium lithium silicate – $Na_2O \cdot Li_2O \cdot 2SiO_2$ – 211.99 – Rhombic – M.P. 847 (Incong.) (576) – R.I. p 1.552, m 1.557, g 1.571 (576)

Sodium lithium silicate – $Na_2O \cdot Li_2O \cdot 2SiO_2$ (Glass) – 211.99 – Colorless – R.I. 1.539 (Quenched) (576)

Sodium lithium sulfate – $NaLiSO_4$ – 126.00 – Colorless – Hexagonal – D 2.369^{20} (348)

Sodium lithium tungstate – $3Na_2O \cdot Li_2O \cdot 4WO_3$ – 1143.53 – M.P. 511 (Incong.) (447)

Sodium magnesium aluminum fluoride – $2NaF \cdot MgF_2 \cdot AlF_3$ (Nat. weberite) – 230.29 – Colorless – Monoclinic – D 2.96 (109) – R.I. p 1.346, m 1.348, g 1.350 (109)

Sodium magnesium carbonate – $Na_2CO_3 \cdot MgCO_3$ – 190.33 – Colorless – Tetragonal – D 2.734 (255) – M.P. 677 (1240 atms.) (255) – R.I. o 1.594, e $<$ 1.54 (255)

Sodium magnesium fluoride – $NaF \cdot MgF_2$ – 85.32 – Colorless – M.P. 1030 (376)

Sodium magnesium phosphate – $Na_2O \cdot MgO \cdot P_2O_5$ – 244.35 – Cubic – D 2.2 (469)

Sodium magnesium phosphate – $Na_2O \cdot 2MgO \cdot P_2O_5$ – 284.67 – Colorless – D 2.5 (469)

Sodium magnesium phosphate – $2Na_2O \cdot MgO \cdot P_2O_5$ – 306.34 – Cubic – D 2.2 (756)

Sodium magnesium silicate – $Na_2O \cdot MgO \cdot SiO_2$ – 162.37 – Colorless – Cubic – R.I. 1.523 (117)

Sodium magnesium silicate – $Na_2O \cdot 2MgO \cdot 2SiO_2$ – 262.75 – Colorless – Monoclinic – R.I. p 1.641, m –, g 1.654 (117)

Sodium magnesium silicate – $Na_2O \cdot 2MgO \cdot 6SiO_2$ – 502.99 – Monoclinic – R.I. p 1.540, m –, g 1.546 (117)

Sodium magnesium sulfate – $Na_2SO_4 \cdot MgSO_4$ – 262.44 – Colorless – M.P. 670 (237) – T.P. 625 (237) – R.I. o 1.650, e 1.450 (237)

Sodium magnesium sulfate – $3Na_2SO_4 \cdot MgSO_4$ (Nat. vanthoffite) – 546.54 – Colorless – Monoclinic – D 2.69 (469) – R.I. p 1.485, m 1.488, g 1.489 (469)

Sodium manganate, per- – $NaMnO_4$ – 141.93 – Purple – D 2.47^{25} (208) – D.T. 170 (208)

Sodium manganese (II) phosphate – $Na_2O \cdot MnO \cdot P_2O_5$ – 274.96 – D 2.9 (469)

Sodium manganese (II) phosphate – $Na_2O \cdot 2MnO \cdot P_2O_5$ (Nat. natrophilite) – 345.89 – Rhombic – D 3.41 (469) – R.I. p 1.671, m 1.674, g 1.684 (469)

Sodium manganese (II) phosphate – $2Na_2O \cdot MnO \cdot P_2O_5$ – 336.95 – D 2.7 (469)

Sodium molybdate – $Na_2O \cdot MoO_3$ – 205.94 – Colorless – D 3.28^{18} (53)

Sodium molybdate – $Na_2O \cdot MoO_3$(I) – 205.94 – Colorless – M.P. 687 (521)

Sodium molybdate – $Na_2O \cdot MoO_3$(II) – 205.94 – Colorless – Transition to I 621 (447)

Sodium molybdate – $Na_2O \cdot MoO_3$(III) – 205.94 – Colorless – Transition to II 580 (447)

Sodium molybdate – $Na_2O \cdot MoO_3$(IV) – 205.94 – Colorless – Transition to III 423 (447)

Sodium molybdate, di- – $Na_2O \cdot 2MoO_3$ – 349.89 – Colorless – Needle – M.P. 612 (469)

Sodium neodymium silicate – $Na_2O \cdot Nd_2O_3 \cdot 2SiO_2$ – 518.65 – Hexagonal – R.I. o 1.889, e 1.861 (256)

Sodium nitrate – $NaNO_3$ – 85.01 – Colorless – Trigonal – D 2.263^{23} (457) – M.P. 305.5 (634) – R.I. o 1.5845, e 1.3360 (469)

Sodium nitrate hydroxide – $NaNO_3 \cdot NaOH$ – 125.02 – Colorless – M.P. 260 (835)

Sodium nitrate hydroxide – $NaNO_3 \cdot 2NaOH$ – 165.03 – Colorless – M.P. 260 (835)

Sodium nitrite – $NaNO_2$ – 69.01 – Colorless – Rhombic – D 2.144 (157) – M.P. 284 (263) – T.P. 165 (157) – D.T. 370 (157) – R.I. p 1.354, m 1.460, g 1.648 (1121)

Sodium oxalate – $Na_2C_2O_4$ – 134.01 – Colorless – D 2.335 (411) – R.I. p 1.410, m 1.528, g 1.587 (411)

Sodium oxide – Na_2O – 61.99 – Colorless – Cubic – D 2.27 (469) – D.T. 1275 (600 mm.) (636)

Sodium oxide, per- – Na_2O_2 – 77.99 – Colorless – D 2.5 (469) – M.P. 460 (175) – D.T. 657 (760 mm.) (175)

Sodium oxide, per-, hydrate – $Na_2O_2 \cdot 8H_2O$ – 222.12 – Colorless – Hexagonal, monoclinic – D 1.61 (571) – D.T. 30 (469)

Sodium phosphate, meta- – $Na_2O \cdot P_2O_5$(I) – 204.03 – M.P. 625 (764) – R.I. p 1.474, m –, g 1.480 (764)

Sodium phosphate, meta- – $Na_2O \cdot P_2O_5$(II) – 204.03 – Transition to I 475-500 (764) – R.I. p 1.502, m –, g 1.525 (764)

Sodium phosphate, meta- – $Na_2O \cdot P_2O_5$(III) – 204.03 – Colorless – D 2.476 (469) – Transition to II 400-425 (764) – R.I. p 1.502, m –, g 1.525 (764)

Sodium phosphate, meta- – $Na_2O \cdot P_2O_5$ (Glass) – 204.03 – Colorless – D 2.484^{20} (979)

Sodium phosphate, pyro- – $2Na_2O \cdot P_2O_5$(I) – 266.03 – M.P. 985 (764)

Sodium phosphate, pyro- – $2Na_2O \cdot P_2O_5$(II) – 266.03 – Transition to I 545 (764)

Sodium phosphate, pyro- – $2Na_2O \cdot P_2O_5$(III) – 266.03 – Transition to II 518 (764)

Sodium phosphate, pyro- – $2Na_2O \cdot P_2O_5$(IV) – 266.03 – Transition to III 509 (764)

Sodium phosphate, pyro- – $2Na_2O \cdot P_2O_5(V)$ – 266.03 – Colorless – D 2.45 (469) – Transition to IV 398 (764) – R.I. p 1.475, m –, g 1.496 (764)

Sodium phosphate, ortho- – $3Na_2O \cdot P_2O_5$ – 328.02 – Colorless – D $2.537^{17.5}$ (469) – M.P. 1340 (469) – T.P. 700 (1125)

Sodium phosphate – $5Na_2O \cdot 3P_2O_5(I)$ – 736.08 – M.P. 620 (Incong.) (764) – R.I. p 1.471, m –, g 1.500 (764)

Sodium phosphate – $5Na_2O \cdot 3P_2O_5(II)$ – 736.08 – Colorless – Transition to I 515 (764) – R.I. p 1.471, m –, g 1.500 (764)

Sodium phosphate, hydrate – $Na_2O \cdot P_2O_5 \cdot H_2O$ – 222.05 – Colorless – Monoclinic – D 1.862 (469) – D.T. 220 (469)

Sodium phosphate, hydrate – $Na_2O \cdot P_2O_5 \cdot 4H_2O$ – 276.08 – Colorless – Triclinic – D 2.48 (348)

Sodium phosphate, hydrate – $Na_2O \cdot P_2O_5 \cdot 4H_2O$ – 276.08 – Colorless – Rhombic – D 2.04 (469) – M.P. 190 (Incong.) (469) – R.I. p 1.456, m 1.485, g 1.487 (469)

Sodium phosphate, hydrate – $Na_2O \cdot P_2O_5 \cdot 6H_2O$ – 308.12 – Colorless – Rhombic – D 1.91 (469) – M.P. $\sim$ 60 (469) – R.I. p 1.440, m 1.463, g 1.482 (469)

Sodium phosphate, hydrate – $Na_2O \cdot P_2O_5 \cdot 7H_2O$ – 326.13 – Colorless – Monoclinic – D 1.848 (469) – R.I. p 1.460, m 1.465, g 1.465 (469)

Sodium phosphate, hydrate – $2Na_2O \cdot P_2O_5 \cdot 5H_2O$ – 356.11 – Colorless – Hexagonal – D 1.848 (469)

Sodium phosphate, hydrate – $2Na_2O \cdot P_2O_5 \cdot 10H_2O$ – 446.19 – Colorless – Monoclinic – D 1.82 (469) – R.I. p 1.450, m 1.453, g 1.460 (469)

Sodium phosphate, hydrate – $2Na_2O \cdot P_2O_5 \cdot 11H_2O$ – 464.21 – Colorless – Rhombic – R.I. p –, m 1.443, g – (469)

Sodium phosphate, hydrate – $2Na_2O \cdot P_2O_5 \cdot 15H_2O$ – 536.27 – Colorless – Monoclinic – D 1.679 (469) – R.I. p 1.441, m 1.442, g 1.453 (469)

Sodium phosphate, hydrate – $2Na_2O \cdot P_2O_5 \cdot 25H_2O$ – 716.43 – Colorless – Monoclinic – D 1.52^{17} (469) – M.P. 34.6 (469) – R.I. p 1.432, m 1.436, g 1.437 (469)

Sodium phosphate, hydrate – $3Na_2O \cdot P_2O_5 \cdot 24H_2O$ – 760.40 – Colorless – Trigonal – D 1.63 (348) – M.P. 73.4 (Incong.) (469) – R.I. o 1.446, e 1.452 (469)

Sodium phosphate, hydrate – $3Na_2O \cdot 2P_2O_5 \cdot 33H_2O$ – 1064.58 – Colorless – M.P. 55 (469)

Sodium phosphate, hydrate – $5Na_2O \cdot 3P_2O_5 \cdot 12H_2O$ – 952.27 – Colorless – Triclinic – D 2.12 (115)

Sodium phosphate, fluo-, hydrate – $NaF \cdot PF_5 \cdot H_2O$ – 186.03 – D 2.369^{19} (613)

Sodium praseodymium (IV) oxide – $Na_2O \cdot PrO_2$ – 234.91 – Cubic – D 4.60 (1126)

Sodium praseodymium silicate – $Na_2O \cdot Pr_2O_3 \cdot 2SiO_2$ – 511.95 – Hexagonal – R.I. o 1.889, e 1.861 (256)

Sodium rhenate, per- – $Na_2O \cdot Re_2O_7$ – 546.62 – Colorless – Hexagonal – M.P. 300 (in O_2) (739)

Sodium samarium silicate – $Na_2O \cdot Sa_2O_3 \cdot 2SiO_2$ – 530.97 – Hexagonal – R.I. o 1.898, e 1.867 (256)

Sodium selenate – $Na_2O \cdot SeO_3$ – 188.95 – Colorless – Rhombic – D 3.10 (469)

Sodium selenate, hydrate – $Na_2O \cdot SeO_3 \cdot 10H_2O$ – 369.12 – Colorless – Monoclinic – D 1.58 (469)

Sodium selenide – Na_2Se – 124.95 – Colorless – Cubic – D 2.6 (1124) – M.P. $>$ 875 (664)

Sodium selenide – Na_2Se_2 – 203.91 – M.P. 495 (664)

Sodium selenide – Na_2Se_3 – 282.87 – M.P. 313 (Incong.) (664)

Sodium selenide – Na_2Se_4 – 361.83 – M.P. 290 (Incong.) (664)

Sodium silicate – $Na_2O \cdot SiO_2$ – 122.05 – Colorless – Rhombic – D 2.614^{25} (89) – M.P. 1089 (573) – R.I. p 1.513, m 1.520, g 1.528 (573)

Sodium silicate – $Na_2O \cdot SiO_2$ (Glass) – 122.05 – Colorless – D 2.570 (703) – R.I. 1.517 (703)

Sodium silicate – $Na_2O \cdot 2SiO_2(I)$ – 182.11 – Colorless – M.P. 874 (469)

Sodium silicate – $Na_2O \cdot 2SiO_2(II)$ – 182.11 – Transition to I 707 (577)

Sodium silicate – $Na_2O \cdot 2SiO_2(III)$ – 182.11 – Colorless – Rhombic – D 2.496^{25} (95) – Transition to II 678 (577) – R.I. p 1.497, m 1.505, g 1.508 (573)

Sodium silicate – $Na_2O \cdot 2SiO_2$ (Glass) – 182.11 – Colorless – D 2.489^{25} (95) – R.I. 1.505 (364)

Sodium silicate – $2Na_2O \cdot SiO_2(I)$ – 184.04 – M.P 1120 (Incong.) (573) – R.I. p 1.524, m –, g 1.537 (573)

Sodium silicate – $2Na_2O \cdot SiO_2(II)$ – 184.04 – Tablet – D 2.5 (215) – Transition to I 960 (215) – R.I. p –, m 1.536, g – (704)

Sodium silicate, hydrate – $Na_2O \cdot SiO_2 \cdot 5H_2O$ – 212.13 – Colorless – Triclinic – D 1.749^{20} (38) – M.P. 72.20 (37) – R.I. p 1.447, m 1.454, g 1.467 (1075)

Sodium silicate, hydrate – $Na_2O\cdot SiO_2\cdot 6H_2O$ – 230.15 – Colorless - Monoclinic – D 1.807^{20} (38) – M.P. 62.85 (37) – R.I. p 1.465, m 1.473, g 1.485 (1075)

Sodium silicate, hydrate – $Na_2O\cdot SiO_2\cdot 8H_2O$ – 266.18 – Colorless – Monoclinic – D 1.672^{20} (38) – M.P. 48.35 (37) – R.I. p 1.457, m 1.463, g 1.465 (1075)

Sodium silicate, hydrate – $Na_2O\cdot SiO_2\cdot 9H_2O$ – 284.20 – Colorless – Rhombic – D 1.646^{20} (38) – M.P. 47.85 (37) – R.I. p 1.451, m 1.455, g 1.460 (1075)

Sodium silicate, boro-, hydrate – $Na_2O\cdot B_2O_3\cdot 4SiO_2\cdot 2H_2O$ (Nat. searlesite) – 407.90 – Colorless – Monoclinic – D 2.44 (296) – R.I. p 1.515, m 1.533, g 1.535 (296)

Sodium silicate, fluo- – $2NaF\cdot SiF_4$ (Malladrite) – 188.05 – Colorless – Hexagonal – D 2.679 (469) – R.I. o 1.3125, e 1.3089 (818)

Sodium silicate phosphate – $4Na_2O\cdot SiO_2\cdot 2P_2O_5$ – 592.10 – M.P. 961 (916)

Sodium strontium aluminum fluoride – $NaF\cdot 3SrF_2\cdot 3AlF_3$ (Nat. jarlite) – 670.80 – Colorless – Monoclinic – D 3.93 (108) – R. I. p 1.427, m 1.433, g 1.435 (108)

Sodium strontium aluminum fluoride – $NaF\cdot 3SrF_2\cdot 3AlF_3$ (Nat. metajarlite) – 670.80 – D 3.781 (108) – R.I. p –, m 1.432, g – (108)

Sodium strontium carbonate – $Na_2CO_3\cdot SrCO_3$ – 253.64 – Colorless – M.P. 750 (469)

Sodium strontium phosphate – $Na_2O\cdot 2SrO\cdot P_2O_5$(I) – 411.29 – Colorless – Tetragonal – D 4.00 (X-ray) (544) (972)

Sodium strontium phosphate – $Na_2O\cdot 2SrO\cdot P_2O_5$(II) – 411.29 – Colorless – Hexagonal – D 2.74 (X-ray) (544) (972)

Sodium strontium titanium silicate – $Na_2O\cdot SrO\cdot TiO_2\cdot 2SiO_2$ (Nat. lamprophyllite) – 365.64 – Rhombic – D 3.45 (360 a) – R.I. p 1.745, m 1.754, g 1.780 (617)

Sodium sulfate – Na_2SO_4(I) – 142.05 – Colorless – Hexagonal – M.P. 884 (469)

Sodium sulfate – Na_2SO_4(II) – 142.05 – Colorless – Transition to I 236, transition to III 228 (572) – R.I. p $<$ 1.465, m –, g 1.480 (572)

Sodium sulfate – Na_2SO_4(III) – 142.05 – Colorless – Rhombic – D 2.697^{25} (581) – Transition to I 247 (572) – R.I. p –, m 1.480-1.485, g – (572)

Sodium sulfate – Na_2SO_4(IV) – 142.05 – Colorless – Monoclinic – Transition to II 230, transition to III 210 (572) – R.I. p $<$ 1.46, m –, g 1.480 (572)

Sodium sulfate – Na_2SO_4(V) (Thenardite) – 142.05 – Colorless – Rhombic – D 2.664^{25} (581) – Transition to IV 197, transition to III 217 (572) – R.I. p 1.467, m 1.473, g 1.481 (1089)

Sodium sulfate, pyro- – $Na_2O\cdot 2SO_3$ – 222.11 – Colorless – D 2.658^{25} (165)

Sodium sulfate, thio- – $Na_2S_2O_3$ – 158.11 – Colorless – Monoclinic – D 1.667 (469)

Sodium sulfate, bi- – $NaHSO_4$ – 120.07 – Colorless – Triclinic – D 2.476^{20} (753) – M.P. 186 (529) – R.I. p 1.43, m 1.46, g 1.47 (112)

Sodium sulfate, hydrate – $Na_2SO_4\cdot 10H_2O$ (Nat. mirabilite) – 322.22 – Colorless – Monoclinic – D 1.48 (469) – R.I. p 1.394, m 1.396, g 1.398 (469)

Sodium sulfate, hydrate – $Na_2SO_4\cdot 10H_2O$ (Glauber's salt) – 322.22 – Colorless – Monoclinic – D 1.464 (469) – T.P. 32.383 (836) (827) – R.I. p 1.396, m 1.4103, g 1.4192 (856)

Sodium sulfate, hydrate – $NaHSO_4\cdot H_2O$ – 138.08 – Colorless – Monoclinic – D 2.117^{20} (753)

Sodium sulfate, thio-, hydrate – $Na_2S_2O_3\cdot 5H_2O$ – 248.20 – Colorless – Monoclinic – D 1.69 (469) – M.P. 48.0 (469) – R.I. p 1.4886, m 1.5079, g 1.536 (469)

Sodium sulfide – Na_2S – 78.05 – Colorless – Cubic – D 1.856 (469) – M.P. 978 (779)

Sodium sulfide – Na_2S_2 – 110.11 – Brownish amber – M.P. 473.9 (779)

Sodium sulfide – Na_2S_4 – 174.23 – Dark yellow – Cubic – M.P. 284.8 (779)

Sodium sulfide, bi- – $NaHS$ – 56.07 – Colorless – (I) Cubic, (II) trigonal – D 1.79 (1070) – D.T. 400 (993)

Sodium sulfite – Na_2SO_3 – 126.05 – Colorless – Hexagonal – D 2.633 (399) – R.I. o 1.565, e 1.515 (1075)

Sodium tantalate – $Na_2O\cdot Ta_2O_5$ – 503.75 – Cubic – D 7.141 (X-ray) (815)

Sodium telluride – Na_2Te – 173.61 – Colorless – D 2.90 (1124) – M.P. 953 (783)

Sodium titanate – $Na_2O\cdot TiO_2$ – 141.89 – M.P. 1030 (1057)

Sodium titanate – $Na_2O\cdot 2TiO_2$ – 221.79 – M.P. 985 (1057)

Sodium titanate – $Na_2O\cdot 3TiO_2$ – 301.69 – Colorless – Monoclinic – D 3.5 (469) – M.P. 1128 (1057)

Sodium titanate – $4Na_2O\cdot 5TiO_2$ – 647.46 – Monoclinic – R.I. p –, m $>$ 1.74, g – (735)

Sodium titanium fluoride – $2NaF\cdot TiF_4$ – 207.90 – M.P. 700 (339)

Sodium titanium silicate – $Na_2O\cdot 2TiO_2\cdot 2SiO_2$ (Ramsayite) – 341.91 – Brown – D 3.43 (617) – M.P. 624 (340) – R.I. p 1.91, m 2.01, g 2.03 (617)

Sodium titanium silicate – $2Na_2O \cdot 5TiO_2 \cdot 4SiO_2$ – 1003.96 – Prismatic – D 2.88 (320) – R.I. p 1.623, m –, g 1.655 (320)

Sodium tungstate – $Na_2O \cdot WO_3(I)$ – 293.91 – M.P. 695.5 (358)

Sodium tungstate – $Na_2O \cdot WO_3(II)$ – 293.91 – Transition to I 588.8 (358)

Sodium tungstate – $Na_2O \cdot WO_3(III)$ – 293.91 – Rhombic – D 5.13^{30} (358) – Transition to II 586 (33) (358) – R.I. p –, m 1.678, g – (358)

Sodium tungstate – $Na_2O \cdot 2WO_3$ – 525.83 – Rhombic – M.P. 738 (643) – T.P. 547 (643)

Sodium tungstate – $Na_2O \cdot 4WO_3$ – 989.67 – M.P. 784 (Incong.) (447)

Sodium tungsten phosphate – $Na_2O \cdot 2WO_3 \cdot P_2O_5$ – 667.87 – M.P. 850 (348)

Sodium uranate – $Na_2O \cdot 3UO_3$ – 920.20 – Bronze color – Rhombic – D 6.912 (469)

Sodium vanadate, meta- – $Na_2O \cdot V_2O_5$ – 243.90 – Monoclinic – D 2.79 (469) – M.P. 562 (469)

Sodium vanadate, pyro- – $2Na_2O \cdot V_2O_5$ – 305.89 – Hexagonal – M.P. 654 (469)

Sodium vanadate, ortho- – $3Na_2O \cdot V_2O_5$ – 367.88 – Colorless – M.P. $\sim$ 866 (469)

Sodium vanadate – $Na_2O \cdot V_2O_4 \cdot 5V_2O_5$ – 1137.40 – Rhombic – M.P. $\sim$ 800 (Incong.) (469)

Sodium vanadate, hydrate – $3Na_2O \cdot V_2O_5 \cdot 20H_2O$ – 728.20 – Colorless – Hexagonal – R.I. o 1.5398, e 1.5475 (469)

Sodium vanadate, hydrate – $3Na_2O \cdot V_2O_5 \cdot 20H_2O$ – 728.20 – Cubic – R.I. 1.5305 (469)

Sodium vanadate, hydrate – $3Na_2O \cdot V_2O_5 \cdot 24H_2O$ – 800.26 – Hexagonal – D 1.62 (184) – R.I. o 1.5095, e 1.5232 (469)

Sodium yttrium fluoride – $NaF \cdot YF_3$ – 187.92 – D 4.21 (746)

Sodium yttrium silicate – $Na_2O \cdot Y_2O_3 \cdot 2SiO_2$ – 225.84 – Colorless – Hexagonal – R.I. o 1.832, e 1.804 (256)

Sodium zinc phosphate – $Na_2O \cdot ZnO \cdot P_2O_5$ – 285.41 – Colorless – Rhombic – D 3.1 (756)

Sodium zinc phosphate – $2Na_2O \cdot ZnO \cdot P_2O_5$ – 347.40 – Colorless – Cubic – D 2.8 (469)

Sodium zinc phosphate – $Na_2O \cdot 2ZnO \cdot P_2O_5$ – 366.79 – Colorless – Rhombic – D 3.3 (469)

Sodium zirconate – $Na_2O \cdot ZrO_2$ – 185.21 – Rhombic – D 4.0 (215) – M.P. $\sim$ 1500 (Incong.) (215) – R.I. p 1.720, m –, g $>$ 1.80 (215)

Sodium zirconium silicate – $Na_2O \cdot ZrO_2 \cdot SiO_2$ – 245.27 – Rhombic – D 3.605^{24} (215) – M.P. 1477 (215) – R.I. p 1.741, m –, g 1.790 (215)

Sodium zirconium silicate – $Na_2O \cdot ZrO_2 \cdot 2SiO_2$ – 305.33 – Rhombic – R.I. p 1.688, m –, g 1.710 (215)

Sodium zirconium silicate – $2Na_2O \cdot 2ZrO_2 \cdot 3SiO_2$ – 650.60 – Trigonal – D 2.880^{21} (215) – R.I. o 1.715, e 1.692 (215)

Strontium – Sr – 87.63 – Yellowish – Cubic – D 2.6^{20} (15) – M.P. 770 (14) (1026) – B.P. 1384 (15)

Strontium aluminate – $SrO \cdot Al_2O_3$ – 205.57 – White – Prism – M.P. 2015 (1052) – R.I. p 1.649, m –, g 1.663 (1009)

Strontium aluminate – $SrO \cdot 2Al_2O_3$ – 307.51 – Colorless – Monoclinic – D 3.03 (X-ray) (604) – R.I. p 1.614, m –, g 1.640 (1009)

Strontium aluminate – $SrO \cdot 6Al_2O_3$ – 715.27 – White – Hexagonal – D 3.538 (1012) R.I. o 1.702, e 1.860 (1012)

Strontium aluminate – $3SrO \cdot Al_2O_3$ – 412.83 – Cubic – D 3.50 (X-ray) (604) – R.I. 1.728 (1009)

Strontium aluminate – $3SrO \cdot 16Al_2O_3$ – 1941.93 – Hexagonal – D 4.22 (X-ray) (604) (972)

Strontium aluminum silicate – $SrO \cdot Al_2O_3 \cdot 2SiO_2$ – 325.69 – Colorless – Triclinic – D 3.118 (232) – M.P. 1660 (232) – R.I. p 1.574, m 1.582, g 1.586 (262)

Strontium arsenate – $3SrO \cdot As_2O_5$ – 540.71 – Colorless – Rhombic – D 4.60 (378) – M.P. 1635 (378)

Strontium arsenate, hydrate – $2SrO \cdot As_2O_5 \cdot H_2O$ – 455.08 – Colorless – Triclinic – D 4.035^{15} (908) – Transition to $Sr_2As_2O_7$ at 360 (448) – R.I. p 1.635, m –, g 1.67 (319)

Strontium beryllium fluoride – $SrF_2 \cdot BeF_2$ – 172.65 – Colorless – Rhombic – D 3.736^{30} (826)

Strontium borate – $SrO \cdot B_2O_3$ – 173.27 – Colorless – Needle – D 3.34 (659) – M.P. 1100 (469)

Strontium borate – $SrO \cdot 2B_2O_3$ – 242.91 – Colorless – Needle – M.P. 930 (469)

Strontium borate – $2SrO \cdot B_2O_3$ – 276.90 – Colorless – Prism – M.P. 1130 (469)

Strontium borate, fluo- – $SrF_2 \cdot 2BF_3$ – 261.27 – Colorless – Cubic and diaxial – R.I. $<$ 1.44 (227)

Strontium carbonate – $SrCO_3(I)$ – 147.64 – Colorless – Hexagonal – D.T. 1250 (760 mm.) (520)

Strontium carbonate – $SrCO_3(II)$ (Strontianite) – 147.64 – Colorless – Rhombic – D 3.7365^{25} (71) – Transition to I 925 (1122) – R.I. p 1.5155, m 1.664, g 1.666 (469)

Strontium chlorate – $Sr(ClO_3)_2$ – 254.54 – Colorless – Rhombic (also monoclinic) – D 3.152 (469) – M.P. 120 (Incong.) (469) – R.I. p 1.567, m 1.605, g 1.626 (469)

Strontium chloride – $SrCl_2$ – 158.54 – Colorless – Cubic – D 3.052 (469) – M.P. 873 (469) – B.P. 1250 (892) – R.I. 1.64986 (25°C.) (1086)

Strontium chloride oxide – $SrCl_2 \cdot 2SrO$ – 365.80 – Colorless – Melts incong. (727) – T.P. 1022 (727)

Strontium chloride oxide – $4SrCl_2 \cdot SrO$ – 737.79 – M.P. 995 (727)

Strontium chromate – $SrO \cdot CrO_3$ – 203.64 – Pale yellow – Monoclinic – D 3.895^{18} (469)

Strontium ferrite – $SrO \cdot Fe_2O_3$ – 263.31 – Hexagonal – D 5.0 (433)

Strontium fluoride – SrF_2 – 125.63 – Colorless – Cubic – D 4.286 (1086) – M.P. 1400 (521) – B.P. 2460 (876) – R.I. 1.442 (1086)

Strontium formate – $Sr(HCO_2)_2$ – 177.67 – Colorless – Rhombic – D 2.696 (26) – M.P. 719 (469) – R.I. p 1.543, m 1.552, g 1.574 (26)

Strontium hafnate – $SrO \cdot HfO_2$ – 314.23 – Cubic – D 7.70 (X-ray) (449)

Strontium hydroxide – $Sr(OH)_2$ – 121.65 – Colorless – D 3.305 (740) – M.P. 535 (1082) – D.T. 710 (760 mm.) (977)

Strontium hydroxide, hydrate – $Sr(OH)_2 \cdot 8H_2O$ – 265.78 – Colorless – Tetragonal – D 1.90 (469) – R.I. o 1.4991, e 1.4758 (469)

Strontium molybdate – $SrO \cdot MoO_3$ – 247.58 – Colorless – Tetragonal – D 4.145 (469) – R.I. o, e $\sim$ 1.91 (469)

Strontium nitrate – $Sr(NO_3)_2$ – 211.65 – Colorless – Cubic – D 2.986 (469) – M.P. 615 (1082) – R.I. 1.5878 (57) (1096)

Strontium nitrate, hydrate – $Sr(NO_3)_2 \cdot H_2O$ – 229.68 – Colorless – Cubic – R.I. 1.5888 (260)

Strontium nitrate, hydrate – $Sr(NO_3)_2 \cdot 4H_2O$ – 283.71 – Colorless – Monoclinic – D 2.2 (469)

Strontium nitrite – $Sr(NO_2)_2$ – 179.63 – Needle – D 2.997^0 (157) – M.P. 276 (157) – D.T. 350 (157)

Strontium oxide – SrO – 103.63 – Colorless – Cubic and rhombic – D 4.7 (Cubic) (469) – M.P. 2430 (469) – B.P. $\sim$ 3000 (712) – R.I. 1.870 (384)

Strontium oxide, per- – SrO_2 – 119.63 – Colorless – Dimorphous – D 4.45 (62) – D.T. 215 (760 mm.) (1024)

Strontium phosphate, ortho- – $3SrO \cdot P_2O_5$ – 452.93 – Colorless – M.P. 1767 (521)

Strontium phosphate, hydrate – $2SrO \cdot P_2O_5 \cdot H_2O$ – 367.32 – Colorless – Rhombic – D 3.544 (469) – R.I. p 1.608, m –, g 1.625 (320)

Strontium phosphate chloride – $3Sr_3(PO_4)_2 \cdot SrCl_2$ – 1517.33 – Colorless – Hexagonal – D 4.87 (1079) – M.P. $>$ 1560 (1079) – R.I. o 1.650, e 1.655 (1079)

Strontium phosphate fluoride – $3Sr_3(PO_4)_2 \cdot SrF_2$ – 1484.42 – Colorless – Hexagonal – M.P. $>$ 1580 (1079) – R.I. o 1.621, e 1.619 (1079)

Strontium selenate – $SrO \cdot SeO_3$ – 230.59 – Transparent – Rhombic – D 4.25 (417)

Strontium selenide – SrSe – 166.59 – Colorless – Cubic – D 4.38 (417) – R.I. 2.220 (384)

Strontium silicate – $SrO \cdot SiO_2$ – 163.69 – Monoclinic or pseudohexagonal – D 3.65 (469) – M.P. 1580 (469) – R.I. o 1.599, e 1.637 (262)

Strontium silicate – $SrO \cdot SiO_2$ (Glass) – 163.69 – Colorless – D 3.537 (703) – R.I. 1.632 (615)

Stronthium silicate – $SrO \cdot 2SiO_2$ (Glass) – 223.75 – Colorless – D 3.201 (703) – R.I. 1.584 (703)

Strontium silicate – $2SrO \cdot SiO_2$ – 267.32 – Monoclinic – D 3.84 (469) – M.P. $>$ 1750 (469) – R.I. p 1.7275, m 1.732, g 1.756 (262)

Strontium silicate, fluo-, hydrate – $SrSiF_6 \cdot 2H_2O$ – 265.72 – Monoclinic – D $2.99^{17.8}$ (469)

Strontium sulfate – $SrSO_4$(I) – 183.69 – Colorless – Monoclinic – M.P. 1605 (Incong.) (363)

Strontium sulfate – $SrSO_4$(II) (Celestite) – 183.69 – Colorless – D 3.96 (469) – Transition to I 1152 (363) – R.I. p 1.6220, m 1.6237, g 1.6309 (469)

Strontium sulfide – SrS – 119.69 – Colorless transparent – Cubic – D 3.70 (469) – M.P. $>$ 2000 (1000) – R.I. 2.107 (384)

Strontium telluride – SrTe – 215.24 – Cubic – D 4.83 (384) – R.I. 2.408 (384)

Strontium tin (IV) oxide – $SrO \cdot SnO_2$ – 254.33 – Cubic – D 6.39 (X-ray) (449)

Strontium titanate – $SrO \cdot TiO_2$ – 183.53 – Cubic – D 5.11 (X-ray) (449)

Strontium tungstate – $SrO \cdot WO_3$ – 335.55 – Colorless – Tetragonal – D 6.184 (469)

Strontium zirconate – $SrO \cdot ZrO_2$ – 226.85 – Cubic – D 5.48 (449) – M.P. $>$ 2700 (1055)

Sulfur – S – 32.06 – Yellow – Rhombic – D 2.07^{20} (15) – M.P. 112.8 (14) (1026) – Transition to monoclinic S 95.5 (523) – R.I. p 1.958, m 2.0377, g 2.2454 (612)

Sulfur – S – 32.06 – Yellow – Monoclinic – D 1.95 (1075) – M.P. 119.2 (14) (1026) – B.P. 444.6 (15) – R.I. p –, m 1.96, g – (1075)

Sulfur fluoride – SF_2 – 70.06 – Colorless gas – B.P. — 35 (612)

Sulfur fluoride – SF_4 – 108.06 – Colorless gas – M.P. — 124 (612) – B.P. — 40 (612)

Sulfur fluoride – S_2F_{10} – 254.12 – Colorless liquid – D 2.08^0 (224) – M.P. — 92 (224) – B.P. 29 (224)

Sulfur fluoride – SF_6 – 146.06 – Colorless gas – D 1.878^{-50} (781) – M.P. —50.8 (914) – S.P. —63.5 (519)
Sulfur oxide, di- – SO_2 – 64.06 – Colorless gas – D 1.928^{-191} (80) – M.P. —75.46 (334) – B.P. —10.02 (334) – R.I. 1.410 (469)
Sulfur oxide, tri- – SO_3(I) – 80.06 – Colorless – Ice-like – M.P. 17 (521) – B.P. 44.8 (519) – R.I. 1.4097 (675)
Sulfur oxide, tri- – SO_3(II) – 80.06 – Colorless – Asbestos-like – D 1.97^{20} (749) – M.P. 32.4 (521) – B.P. 44.8 (519)
Sulfur oxide, tri- – SO_3(III) – 80.06 – Colorless – Asbestos-like – M.P. 62.2 (521) – S.P. 51.6 (519)
Tantalum – Ta – 180.88 – Silvery white – Cubic – D 16.61^{25} (517) – M.P. 3000 (14) (1026) – B.P. 6100 (15)
Tantalum antimonate – $Ta_2O_5 \cdot Sb_2O_3$ – 733.28 – Rhombic – D 7.54 (X-ray) (229) (972)
Tantalum chloride – $TaCl_5$ – 358.17 – Colorless – D 3.68^{27} (469) – M.P. 221 (469) – B.P. 242 (469)
Tantalum fluoride – TaF_5 – 275.88 – Colorless – Prisms – D 4.74 (469) – M.P. 96.8 (469) – B.P. 230 (519)
Tantalum oxide – Ta_2O_5 – 441.76 – Colorless – Rhombic – D 8.015^{25} (612) – M.P. 1875 (870)
Tantalum sulfide – TaS_2 – 245.00 – D 6.86^{25} (84) – S.P. $>$ 1000 (84)
Tantalum sulfide – TaS_3 – 277.06 – D 5.725^{25} (84) – D.T. $>$ 600 (84)
Tellurium – Te – 127.61 – Silvery – Hexagonal – D 6.24^{20} (15) – M.P. 449.8 (578) – B.P. 1087.2 (15) – R.I. o 2.68, e 3.07 (610)
Tellurium chloride – $TeCl_4$ – 269.44 – Colorless – D 3.26^{18} (53) – M.P. 225 (937) – B.P. 392 (519)
Tellurium fluoride – TeF_6 – 241.61 – Colorless – D $2.67^{\text{M.P.}}$ (Liquid) $3.76^{\text{M.P.}}$ (Solid) (549) – M.P. —37.8 – T.P. —73.5 (1099) – S.P. —38.6 (519)
Tellurium oxide, di- – TeO_2 – 159.61 – Colorless – Tetragonal – D 5.66 (469)
Tellurium oxide, di- – TeO_2 – 159.61 – Colorless – Rhombic – D 5.89 (469) – R.I. p 2.00, m 2.18, g 2.35 (All for Li line) (469)
Tellurium oxide, di- – TeO_2 – 159.61 – Colorless – M.P. 732.6 (612) – S.P. 450 (469)
Tellurium oxide, tri- – TeO_3 – 175.61 – Orange yellow – D 5.08 (469)
Tellurium oxide, tri-, hydrate – $TeO_3 \cdot H_2O$ – 193.63 – Colorless – D 3.44 (469) – D.T. 160 (469)
Tellurium oxide, tri-, hydrate – $TeO_3 \cdot 3H_2O$ – 229.66 – Colorless – Cubic – D 3.053 (469)
Tellurium oxide, tri-, hydrate – $TeO_3 \cdot 3H_2O$ – 229.66 – Colorless – Monoclinic – D 3.071 (469) – —H_2O at 300 (772)
Terbium – Tb – 159.2 – M.P. 327 (14) (1026)
Terbium chloride – $TbCl_3$ – 265.57 – Colorless – Needles – D 4.35^{0} (469) – M.P. 588 (469)
Terbium nitrate, hydrate – $Tb(NO_3)_3 \cdot 6H_2O$ – 453.32 – Colorless – Monoclinic – M.P. 89.3 (469)
Terbium oxalate – $Tb_2(C_2O_4)_3$ – 264.06 – Colorless – D 2.60 (662)
Terbium oxide – Tb_2O_3 – 366.40 – Colorless – D 7.68 (662)
Thallium – Tl – 204.39 – Grayish – Hexagonal – D 11.85^{20} (15) – M.P. 300 (14) (1026) – B.P. 1457 (15)
Thallium (I) aluminum fluoride – $TlF \cdot AlF_3$ – 307.36 – Colorless – Tetragonal – D 6.09 (140)
Thallium (I) aluminum fluoride – $2TlF \cdot AlF_3$ – 530.75 – Colorless – Rhombic – D 5.53 (140)
Thallium (I) arsenite, thio- – $Tl_2S \cdot As_2S_3$ (Nat. lorandite) – 686.84 – Red – Monoclinic – D 5.53 (469) – R.I. p $>$ 2.72, m $>$ 2.72, g – (All for Li line)
Thallium (I) beryllium fluoride – $2TlF \cdot BeF_2$ – 493.80 – Colorless – D 6.650^{30} (826)
Thallium (I) borate – $Tl_2O \cdot B_2O_3$ – 494.42 – Colorless – M.P. 472 (168)
Thallium (I) borate – $2Tl_2O \cdot B_2O_3$ – 919.20 – M.P. 434 (168)
Thallium (I) borate – $3Tl_2O \cdot B_2O_3$ – 1343.98 – D.T. 370 (168)
Thallium (I) borate, fluo- – $TlF \cdot BF_3$ – 291.21 – Rhombic and cubic – T.P. 205 (1037)
Thallium (I) carbonate – Tl_2CO_3 – 468.79 – Colorless – Monoclinic – D 7.11 (469) – M.P. 273 (521) – T.P. 228 (1037) – D.T. 368 (760 mm.) (520)
Thallium (I) carbonate nitrate – $Tl_2CO_3 \cdot TlNO_3$ – 735.19 – M.P. 214 (142)
Thallium (I) carbonate nitrate – $Tl_2CO_3 \cdot 2TlNO_3$ – 1001.59 – M.P. 218 (142)
Thallium (I) chloride – TlCl – 239.85 – Colorless – Cubic – D 7.00 (469) – M.P. 427 (521) – B.P. 807 (519) – R.I. 2.247 (44)
Thallium (III) chloride – $TlCl_3$ – 310.76 – Colorless – Hexagonal – M.P. $\sim$ 25 (995)
Thallium (I) cyanate – TlCNO – 246.41 – D 5.487^{20} (467)
Thallium (I) cyanate, seleno- – TlCNSe – 309.37 – D 5.462^{20} (467)

Thallium (I) cyanate, thio- – $TlCNS$ – 262.47 – D 4.956^{20} (467)
Thallium (I) fluoride – TlF – 223.39 – Colorless – Rhombic – D 8.36^{20} (406) – M.P. 327 (406) – B.P. 655 (406)
Thallium (III) fluoride – TlF_3 – 261.39 – Green – D 8.36 (392) – M.P. 550 (392)
Thallium (I) fluoride, acid- – $TlF \cdot HF$ – 243.40 – Cubic – D 5.01 (400)
Thallium (III) formate – $Tl(HCO_2)_3$ – 339.44 – Monoclinic – M.P. 95 (469)
Thallium (I) hydroxide – $TlOH$ – 221.40 – Colorless or yellow – Needle – D.T. 139 (760 mm.) (469)
Thallium (III) hydroxide – $Tl(OH)_3$ – 255.41 – Brown – Hexagonal – M.P. > 340 (469)
Thallium (I) nitrate – $TlNO_3$(I) – 266.40 – Cubic – M.P. 207 (521) – B.P. 430 (469)
Thallium (I) nitrate – $TlNO_3$(II) – 266.40 – Hexagonal – Transition to I 143.5 (135)
Thallium (I) nitrate – $TlNO_3$ – 266.40 – Colorless – Rhombic – Transition to II 61.0 (135) – R.I. p 1.817, m –, g – (135)
Thallium (I, III) nitrate – $2TlNO_3 \cdot Tl(NO_3)_3$ – 923.21 – Colorless – Prismatic – M.P. 150 (1063)
Thallium (I) nitrite – $TlNO_2$ – 250.40 – Yellow – M.P. 182 (277)
Thallium (I) oxide – Tl_2O – 424.78 – Violet black – D 9.52 (52) – M.P. 300 (469) – S.P. 1080 (600 mm.) (636)
Thallium (III) oxide – Tl_2O_3 – 456.78 – Brown and black – Cubic – D 9.65^{21} (Brown) 10.19^{22} (Black) (469) – M.P. 717 (558)
Thallium (I) phosphate, pyro- – $2Tl_2O \cdot P_2O_5$ – 991.60 – Monoclinic – D 6.79 (469) – M.P. > 120 (469)
Thallium (I) phosphate, ortho- – $3Tl_2O \cdot P_2O_5$ – 1416.38 – Colorless – Acicular – D 6.89^{10} (469)
Thallium (I) phosphate, hydrate – $Tl_2O \cdot P_2O_5 \cdot H_2O$ – 584.84 – M.P. 270 (469)
Thallium (I) phosphate, hydrate – $Tl_2O \cdot P_2O_5 \cdot 2H_2O$ – 602.85 – Monoclinic – D 4.72 (469) – M.P. 167 (212) – —H_2O at 185, —$2H_2O$ at 400 (212)
Thallium (I) rhenate, per- – $Tl_2O \cdot Re_2O_7$ – 723.09 – Rhombic – M.P. 527 – T.P. 120 (1036)
Thallium (I) selenate – $Tl_2O \cdot SeO_3$ – 551.74 – Rhombic – D 6.875 (469) – R.I. p 1.9493, m 1.9592, g 1.9640 (469)
Thallium (I) selenide – Tl_2Se – 487.74 – Metallic – Leaf – D 9.05^{25} (558) – M.P. 340 (469)
Thallium (I, III) selenide – $Tl_2Se \cdot Tl_2Se_3$ – 1133.40 – Tetragonal – D 8.175 (534) – M.P. 338 (469)
Thallium (I) silicate, fluo- – $2TlF \cdot SiF_4$ – 550.84 – Cubic – D 5.790 (X-ray) (532)
Thallium (I) silicate, fluo- – $2TlF_3 \cdot 3SiF_4$ – 758.96 – D 5.72 (X-ray) (975)
Thallium (I) sulfate – Tl_2SO_4 – 504.84 – Colorless – Rhombic – D 6.765 (1022) – M.P. 632 (469) – R.I. p 1.8600, m 1.8671, g 1.8853 (469)
Thallium (I) sulfate – Tl_2SO_4 (Glass) – 504.84 – Colorless – D 6.77 (607)
Thallium (I) sulfate, bi- – $TlHSO_4$ – 301.46 – D.T. 120 (469)
Thallium (III) sulfate – $Tl_2(SO_4)_3$ – 696.96 – Rhombic – D 5.22^{15} (53)
Thallium (I) sulfide – Tl_2S – 440.84 – Black – Hexagonal – D 8.40^{25} (558) – M.P. 449 (521)
Thallium (III) sulfide – Tl_2S_3 – 504.96 – Black – M.P. 260 (473)
Thallium sulfide – Tl_2S_5 – 569.08 – Brick red – M.P. 310 (473)
Thallium (I) tellurate – $Tl_2O \cdot TeO_3$ – 600.39 – White – D 6.74^{16} (675)
Thallium (I) telluride – Tl_2Te – 536.39 – M.P. 412 (469)
Thallium (I, III) telluride – $Tl_2Te \cdot Tl_2Te_3$ – 1328.00 – Metallic luster – Needle – D 8.42^{25} (558)
Thallium telluride – Tl_3Te_2 – 868.39 – D 8.99 (558) – M.P. 428 (675)
Thallium (I) vanadate, meta- – $Tl_2O \cdot V_2O_5$ – 606.68 – Dark gray – D 6.02^{17} (171) – M.P. 424 (469)
Thallium (I) vanadate, pyro- – $2Tl_2O \cdot V_2O_5$ – 1031.46 – Light yellow – D 8.21-8.81 (171) – M.P. 454 (469)
Thallium (I) vanadate, ortho- – $3Tl_2O \cdot V_2O_5$ – 1456.24 – Brown – D 8.6^{17} (171) – M.P. 566 (469)
Thallium (I) vanadate – $3Tl_2O \cdot 2V_2O_5$ – 1638.14 – Yellow – D 8.59^{18} (171)
Thorium – Th – 232.12 – Cubic – D 11.5^{20} (15) – M.P. 1800 (14) (1026) – B.P. 5200 (15)
Thorium chloride – $ThCl_4$ – 373.95 – Colorless – Rhombic – D 4.59 (469) – M.P. 770 (282) – B.P. 921 (282)
Thorium columbate – $5ThO_2 \cdot 16Cb_2O_5$ – 5573.72 – Rhombic – D 5.21^{17} (675)
Thorium fluoride – ThF_4 – 308.12 – Colorless – Cubic – B.P. > 1000 (873)
Thorium molybdate – $ThO_2 \cdot 2MoO_3$ – 552.02 – Colorless – Tetragonal – D 7.5 (1114)

Thorium oxide – ThO_2 (Thorianite) – 264.12 – Colorless – Cubic – D 9.69 (469) – M.P. 3050 (1052) – R.I. 2.20 (469)

Thorium phosphate – $ThO_2 \cdot 2P_2O_5$ – 548.20 – Colorless – Rhombic – D 4.08^{16} (469)

Thorium phosphate, hydrate – $3ThO_2 \cdot 2P_2O_5 \cdot 12H_2O$ – 1292.63 – Colorless – — $12H_2O$ at 850 (in vacuum) (174)

Thorium silicate – $ThO_2 \cdot SiO_2$ (Nat. thorite) – 324.18 – Colorless – Tetragonal – D 5.3 (469) – R.I. o 1.80, e 1.81 (1076)

Thorium silicate, hydrate – $ThO_2 \cdot SiO_2 \cdot 4H_2O$ (Nat. hydrothorite) – 396.24 – Cubic – R.I. 1.638 (617)

Thorium sulfate – $Th(SO_4)_2$ – 424.24 – Colorless – D 4.37^{18} (53)

Thorium sulfate, hydrate – $Th(SO_4)_2 \cdot 8H_2O$ – 568.37 – Colorless – Monoclinic – R.I. p –, m 1.5168, g – (1075)

Thorium sulfate, hydrate – $Th(SO_4)_2 \cdot 9H_2O$ – 586.39 – Colorless – Monoclinic – D 2.77 (469)

Thorium sulfide – ThS_2 – 296.24 – Yellow – D 7.234 (790) – M.P. 1925 (790)

Thorium sulfide oxide – ThSO – 280.18 – Yellow – D 6.44 (469)

Thorium zirconate – $ThO_2 \cdot ZrO_2$ – 387.34 – Needle – M.P. $>$ 2800 (828) – R.I. 2.3 (828)

Thulium – Tm (or Tu) – 169.4

Thulium chloride – $TmCl_3$ – 275.77 – Greenish yellow – D 4.34^{25} (540) – M.P. 821 (493)

Thulium oxide – Tm_2O_3 – 386.80 – Colorless with a greenish tinge – Cubic – D 8.77 (X-ray) (1106)

Tin – Sn – 118.70 – Silvery white – Tetragonal – D 7.30^{20} (15) – M.P. 231.9 (14) (1026) – B.P. 2270 (15)

Tin (II) chloride – $SnCl_2$ – 189.61 – Colorless – Rhombic – D 3.952^{25} (75) – M.P. 247 (521) – B.P. 652 (281)

Tin (IV) chloride – $SnCl_4$ – 260.53 – Colorless liquid – Cubic – D 2.226 (Liquid) (469) – M.P. -33.2 (521) – B.P. 113 (519) – R.I. 1.512 (675)

Tin (IV) fluoride – SnF_4 – 194.70 – Colorless – D 4.78 (469) – B.P. 705 (469)

Tin (II) iron (II) silicate – $SnO \cdot FeO \cdot SiO_2$ – 266.61 – M.P. 990 (564)

Tin (II) iron (II) silicate – $3SnO \cdot 4FeO \cdot 6SiO_2$ – 1051.86 – M.P. 970 (564)

Tin (II) oxalate – SnC_2O_4 – 206.72 – Colorless – D 3.56^{18} (469)

Tin (II) oxide – SnO – 134.70 – Gray, brown, green – Cubic – D 6.25 (966) – D.T. 1080 (600 mm.) (636)

Tin (IV) oxide – SnO_2 (Cassiterite) – 150.70 – Yellow – Tetragonal, hexagonal, rhombic – D 7.000^{18} (457) – M.P. $>$ 1900 (1050) – T.P. 400-425 (623) – S.P. 1800-1900 (1050) – R.I. o 1.9975, e 2.0938 (435)

Tin (II) phosphate, meta- – $SnO \cdot P_2O_5$ – 276.74 – D 3.38^{28} (477)

Tin (II) phosphate, pyro- – $2SnO \cdot P_2O_5$ – 411.44 – D 4.01^{16} (477)

Tin (II) phosphate, ortho- – $3SnO \cdot P_2O_5$ – 546.14 – Colorless – D 3.823^{17} (477)

Tin (IV) phosphate – $SnO_2 \cdot P_2O_5$ – 292.74 – Colorless – Cubic – D 3.957 (639)

Tin (II) phosphate, hydrate – $SnO \cdot P_2O_5 \cdot 2H_2O$ – 312.77 – Rhombic – D 3.17^{28} (477)

Tin (II) phosphate, hydrate – $2SnO \cdot P_2O_5 \cdot H_2O$ – 429.46 – D 3.48^{16} (477)

Tin (II) selenide – SnSe – 197.66 – Steel gray – D 6.18 (469) – M.P. 861 (469)

Tin (IV) selenide – $SnSe_2$ – 276.62 – Tin white – D 5.0 (469) – M.P. 650 (675)

Tin (IV) sulfate – $Sn(SO_4)_2$ – 310.82 – Colorless – D 3.45^{18} (53)

Tin (II) sulfide – SnS – 150.76 – Gray – Cubic, monoclinic – D 5.22^{25} (558) – M.P. 880 (469) – B.P. 1230 (469)

Tin (IV) sulfide – SnS_2 – 182.82 – Golden yellow – Hexagonal – D 4.5 (469) – D.T. $\sim$ 600 (322)

Tin (IV) tantalate – $SnO_2 \cdot Ta_2O_5$ (Nat. Thoreaulite) – 592.46 – Monoclinic – D 7.8 (160) – R.I. p –, m 2.38, g – (676)

Tin (II) telluride – SnTe – 246.31 – Gray – D 6.48 (469) – M.P. 780 (469)

Titanium – Ti – 47.90 – White – Hexagonal – D 4.5^{20} (15) – M.P. 1820 (14) (1026) – B.P. 5100 (15)

Titanium chloride – $TiCl_4$ – 189.73 – Colorless – Liquid – D 1.7194^{25} (891) – M.P. -23 (521) – B.P. 136 (519) – R.I. $1.61^{10.5°}$ (469)

Titanium fluoride – TiF_4 – 123.90 – Colorless – D 2.798^{21} (469) – B.P. 284 (469)

Titanium oxide, mono- – TiO – 63.90 – Golden yellow – D 4.93 (216) – M.P. 1750 (216)

Titanium oxide, sesqui- – Ti_2O_3 – 143.80 – Trigonal – D 4.6 (469) – M.P. 1900 (510)

Titanium oxide – $2Ti_2O_3 \cdot 3TiO_2$ – 527.30 – M.P. 1640 (469)

Titanium oxide – TiO_2 (Rutile) – 79.90 – Colorless – Tetragonal – D 4.24 (182) – Transition to brookite at 1300 (510) – R.I. o 2.616, e 2.903 (469)

Titanium oxide – TiO_2 (Brookite) – 79.90 – Colorless to brown – Rhombic – D 4.17 (469) – M.P. 1825 (521) – D.T. 2227 (760 mm.) (510) – R.I. p 2.585, m 2.586, g 2.699 (903)

Titanium oxide – TiO_2 (Anatase I) – 79.90 – Tetragonal – Transition to rutile at 915 (902)

Titanium oxide – TiO_2 (Anatase II) – 79.90 – Colorless to brown – Tetragonal – D 3.84 (469) – Transition to I 642 (902) – R.I. o 2.560, e 2.488 (1076)

Titanium phosphate – $TiO_2 \cdot P_2O_5$ – 221.86 – Colorless – Cubic – D 3.106 (X-ray) (639)

Titanium selenide – $TiSe_2$ – 205.82 – Red – Hexagonal – D 5.29 (X-ray) (750)

Titanium sulfate, oxy- – $TiOSO_4$ – 159.96 – Colorless – Rhomboidal – R.I. 1.80-1.89 (107)

Titanium sulfide, mono- – TiS – 79.96 – Dark brown – D 4.12 (77)

Titanium sulfide, sesqui- – Ti_2S_3 – 191.98 – Grayish black – D 3.584 (792)

Titanium sulfide – TiS_2 – 112.02 – Bronze yellow – D 3.22^{20} (77)

Titanium sulfide, tri- – TiS_3 – 144.08 – Graphite appearance – D 3.22^{20} (77)

Titanium telluride – $TiTe_2$ – 303.12 – Reddish – Hexagonal – D 6.24 (X-ray) (750)

Tungsten – W – 183.92 – Grayish black – Cubic – D 19.3^{20} (15) – M.P. 3410 (14) (1026) – B.P. 5930 (15)

Tungsten (IV) chloride – WCl_4 – 325.75 – Grayish brown – D 4.624^{25} (78)

Tungsten (V) chloride – WCl_5 – 361.21 – Black – Needle – D 3.875^{25} (78) – M.P. 248 (469) – B.P. > 300 (1034)

Tungsten (VI) chloride – WCl_6 – 396.66 – Dark violet – Cubic – D 3.542^{19} (457) – M.P. 275 (469) – B.P. 347 (1034)

Tungsten (VI) chloride oxide – WCl_2O_2 – 286.83 – Yellow – Tablets – M.P. 266 (609) – D.T. 484 (475 mm.) (567)

Tungsten (VI) chloride oxide – WCl_4O – 341.75 – Red – Long prismatic needle – M.P. 211 (469) – B.P. 232 (829)

Tungsten (VI) fluoride – WF_6 – 297.92 – Colorless gas or liquid – D $3.427^{B.P.}$ (418) – M.P. 2.3 (420 mm.) (875) – B.P. 17.5 (519)

Tungsten (VI) fluoride oxide – WF_4O – 275.92 – Colorless – Plates – M.P. 110 (469) – B.P. 187 (469)

Tungsten (IV) oxide – WO_2 – 215.92 – Brown – Tetragonal – D 10.9 (70) – M.P. 1280 (in N_2) (306) – B.P. 1730 (10)

Tungsten (VI) oxide – WO_3 – 231.92 – Yellow – Triclinic – D 7.16 (348) – M.P. 1473 (479) – B.P. 1430 (10)

Tungsten (VI) oxide, hydrate – $WO_3 \cdot H_2O$ (Nat. tungstite) – 249.94 – Yellow – Rhombic – D 5.5 (469) – R.I. p 2.09, m 2.24, g 2.26 (469)

Tungsten (IV) sulfide – WS_2 (Nat. tungstenite) – 248.04 – Grayish black – Hexagonal – D 7.5 (469) – D.T. > 1100 (in vacuum) (348)

Uranium – U – 238.07 – White – Rhombic – D 18.7^{20} (15) – M.P. 3600 (14) (1026) – B.P. 3500 (15)

Uranium (IV) chloride – UCl_4 – 379.90 – Light green – Cubic – D 4.860^{19} (457) – M.P. 567 (1034) – B.P. 618 (1034)

Uranium (IV) fluoride – UF_4 – 314.07 – Green – M.P. 1000 (880)

Uranium (VI) fluoride – UF_6 – 352.07 – Colorless or slight yellow – Monoclinic – D 4.68^{21} (469) – M.P. 69.2 (1490 mm.) (880) – B.P. 55.7 (519)

Uranium (IV) oxide – UO_2 – 270.07 – Brown to black – Cubic – D 10.75^{25} (90) – M.P. 2280 (306)

Uranium (IV, VI) oxide – U_3O_8 (Pitchblend) – 842.21 – Black – D 8.2 (90) – Decomposition to UO_2 1300 (90)

Uranium (VI) oxide – UO_3 – 286.07 – Orange – Cubic – D 6.04^{25} (90)

Uranium (VI) oxide, hydrate – $UO_3 \cdot 2H_2O$ (Nat. schoepite) – 322.10 – Yellow – Rhombic – D 4.96 (617) – R.I. p 1.690, m 1.714, g 1.735 (617)

Uranium oxide, hydrate – $UO_4 \cdot 2H_2O$ – 338.10 – Yellowish white – D.T. 115 (469)

Uranium (VI) phosphate, hydrate – $3UO_3 \cdot P_2O_5 \cdot 6H_2O$ (Nat. phosphoruranylite) – 1108.35 – Yellow – Monoclinic – R.I. p 1.691, m 1.720, g 1.720 (469)

Uranium silicate, hydrate – $5U_2O_3 \cdot 2SiO_2 \cdot 6H_2O$ (Nat. soddyite) – 2848.92 – Greenish yellow – Rhombic – D 4.63 (617) – R.I. p 1.530, m 1.68, g 1.710 (617)

Uranium (IV) sulfate – $U(SO_4)_2$ – 430.19 – D 4.60 (53)

Uranium (IV) sulfide – US_2 – 302.19 – Iron gray – Tetragonal – D 7.96^{25} (968) – D.T. 1300 (in vacuum) (789)

Uranium (VI) sulfide – US_3 – 334.25 – Black – D 5.81^{25} (968)

Uranium (VI) vanadate, hydrate – $2UO_3 \cdot 3V_2O_5 \cdot 15H_2O$ (Nat. uvanite) – 1388.08 – Brownish yellow – Rhombic – R.I. p 1.817, m 1.879, g 2.057 (469)

Uranyl carbonate – UO_2CO_3 (Nat. rutherfordine) – 330.08 – Yellow – Tetragonal – D 4.82 (617) – R.I. p 1.72, m 1.75, g 1.80 (469)

Uranyl nitrate – $UO_2(NO_3)_2$ – 394.08 – Yellow – D.T. 160 (540 mm.) (695)

Uranyl nitrate, hydrate – $UO_2(NO_3)_2 \cdot 3H_2O$ – 448.13 – Yellow – Triclinic – M.P. 120 (469)

Uranyl nitrate, hydrate – $UO_2(NO_3)_2 \cdot 6H_2O$ – 502.18 – Yellow – Rhombic – D 2.742 (774) – M.P. 60.2 (348) – R.I. p –, m 1.4967, g – (469)

Uranyl oxalate – $UO_2C_2O_4$ – 358.09 – D 2.98 (469)

Uranyl phosphate – $UO_2 \cdot P_2O_5$ – 412.11 – Slight rose – Cubic – D 4.288 (X-ray) (786)

Uranyl phosphate – $UO_2 \cdot 2P_2O_5$ – 554.15 – Green – Rhombic – D 3.9 (469)

Uranyl sulfate – UO_2SO_4 – 366.13 – D 5.24^{18} (53)

Uranyl sulfate, hydrate – $UO_2SO_4 \cdot 3H_2O$ – 420.18 – Yellow – D 3.28 (469) – D.T. 100

Vanadium – V – 50.95 – Gray – D 5.68^{20} (15) – M.P. 1735 (14) (1026) – B.P. 3000 (15)

Vanadium (II) chloride – VCl_2 – 121.86 – Apple green – Hexagonal – D 3.23^{18} (469)

Vanadium (III) chloride – VCl_3 – 157.32 – Peach blossom – Tabular – D 3.00^{18} (469)

Vanadium (IV) chloride – VCl_4 – 192.78 – Dark reddish-brown liquid – D 1.816^{30} (469) – M.P. —109 (469) – B.P. 148.5 (755 mm.) (83)

Vanadium (V) chloride oxide – VCl_3O – 173.32 – Pale yellow liquid – D 1.829 (469) – M.P. —79.5 (288) – B.P. 127.2 (469)

Vanadium (V) chloride oxide – $VClO_2$ – 118.41 – D 3.64 (469)

Vanadium (III) fluoride – VF_3 – 107.95 – Greenish yellow – Rhombic – D 3.363^{19} (469) – M.P. > 800 (675)

Vanadium (IV) fluoride – VF_4 – 126.95 – Brownish yellow – D 2.975^{23} (469) – D.T. 325 (469)

Vanadium (V) fluoride – VF_5 – 145.95 – Colorless – D 2.177^{19} (469) – B.P. 111.2 (758 mm.) (469)

Vanadium (IV) fluoride oxide – VF_2O – 104.95 – Yellow – D 3.396^{19} (469)

Vanadium (V) fluoride oxide – VF_3O – 123.95 – Yellowish white – D 2.459^{21} (469) – M.P. 300 (469) – B.P. 480 (469)

Vanadium (II) oxide – VO – 66.95 – D 5.231^{25} (612)

Vanadium (III) oxide – V_2O_3 – 149.90 – Black – D 4.87^{18} (469) – M.P. 1970 (469)

Vanadium (IV) oxide – V_2O_4 – 165.90 – Dark blue – D 4.654^{25} (612) – M.P. 1637 (306)

Vanadium (V) oxide – V_2O_5 – 181.90 – Reddish yellow – Rhombic – D 3.357 (469) – M.P. 800 (469) – D.T. 1750 (675) – R.I. p 1.46, m 1.52, g 1.76 (Calc.) (533)

Vanadium (II) sulfide – VS – 83.01 – Brownish black – Hexagonal – D 4.28 (85)

Vanadium (III) sulfide – V_2S_3 – 198.08 – Black – D 4.7 (469) – D.T. > 660 (330)

Vanadium (V) sulfide – V_2S_5 – 262.20 – Black – D 3.00 (469) – —2S at 350-500 (330)

Water – H_2O – 18.0160 – Colorless liquid – D 1.0000000^4 (235) – M.P.0° or 273.16°K. (14) – B.P. 100 or 373.165°K. (14) – R.I. 1.332502^{25} (Against air) (1006)

Water, heavy – HDO – 19.0216 – Colorless liquid – M.P. 2.23 (Calc.) (336) – B.P. 100.76 (839)

Water, heavy – D_2O – 20.02726 – Colorless liquid – D 1.10763^{25}_{25} (499) – M.P. 3.82 (985) – B.P. 101.42 (640) – R.I. 1.32844^{20} (653)

Water, heavy – H_2O^{18} – 20.0160 – Colorless liquid – M.P. —0.1 (Calc.) (336) – B.P. 100.13 (839)

Ytterbium – Yb – 173.04 – D 7.03 (114)

Ytterbium carbonate, hydrate – $Yb_2(CO_3)_3 \cdot 4H_2O$ – 598.17 – D 3.67 (469)

Ytterbium (II) chloride – $YbCl_2$ – 243.95 – Slight reddish yellow – Rhombic – D 5.08 (555)

Ytterbium chloride – $YbCl_3$ – 279.41 – D 3.781^{25} (446) – M.P. 854 (494)

Ytterbium nitrate, hydrate – $Yb(NO_3)_3 \cdot 4H_2O$ – 604.16 – D 2.682 (469)

Ytterbium oxalate – $Yb_2(C_2O_4)_3$ – 610.14 – D 2.439 (469)

Ytterbium oxide – Yb_2O_3 – 394.08 – Colorless – D 9.17 (469)

Ytterbium selenate – $Yb_2O_3 \cdot 3SeO_3$ – 726.96 – D 4.14 (469)

Ytterbium selenate, hydrate – $Yb_2O_3 \cdot 3SeO_3 \cdot 8H_2O$ – 919.09 – Hexagonal – D 3.30 (469)

Ytterbium selenide – Yb_2Se_3 – 582.96 – Violet black – Cubic – D 7.33 (551)

Ytterbium sulfate – $Yb_2(SO_4)_3$ – 634.26 – Colorless – D 3.793 (469)

Ytterbium sulfate, hydrate – $Yb_2(SO_4)_3 \cdot 8H_2O$ – 778.39 – Prism – D 3.315^{20} (423)

Ytterbium sulfide – Yb_2S_3 – 442.26 – Light yellow – D 6.02^{25} (552)

Yttrium – Y – 88.92 – Iron gray – Hexagonal – D 5.51^{20} (15) – M.P. 1490 (14) (1026) – B.P. 4600 (15)

Yttrium arsenate – $Y_2O_3 \cdot As_2O_5$ – 455.66 – Yellowish white – Tetragonal – D 4.56^{20} (965)

Yttrium chloride – YCl_3 – 195.29 – Colorless – D 2.81 (540) – M.P. 721 (491)

Yttrium columbate – $Y_2O_3 \cdot Cb_2O_5$ – 491.66 – Tetragonal – D 4.07 (X-ray) (675) (972)

Yttrium fluoride – YF_3 – 145.92 – Colorless – Monoclinic – D 5.2 (746)

Yttrium fluoride – YF_3 – 145.92 – Colorless – Cubic – D 4.01 (744)

Yttrium molybdate – $Y_2O_3 \cdot 3MoO_3$ – 654.99 – Colorless or yellowish – Tetragonal – D 4.79^{16} (469) – M.P. 1347 (469) – R.I. o –, e 2.031 (Lambda = 5700) (1075)

Yttrium oxide – Y_2O_3 – 225.84 – Colorless – D 4.84^{15} (469) – M.P. 2410 (469) – B.P. 4300 (712)

Yttrium phosphate – $Y_2O_3 \cdot P_2O_5$ (Xenotime) – 367.88 – Tetragonal – D 3.78 (965) – R.I. o 1.721, e 1.816 (469)

Yttrium phosphate – $2Y_2O_3 \cdot 3P_2O_5$ – 877.80 – D 3.059 (469)

Yttrium selenide – Y_2Se_3 – 414.72 – Gray black – D $\sim$ 5.13 (551)

Yttrium silicate – $Y_2O_3 \cdot SiO_2$ – 285.90 – Monoclinic (341)

Yttrium silicate – $Y_2O_3 \cdot 2SiO_2$ – 345.96 – Monoclinic (341)

Yttrium silicate, hydrate – $2Y_2O_3 \cdot 4SiO_2 \cdot H_2O$ (Nat. thalenite) – 709.94 – Monoclinic – D 4.3 (617) – R.I. p 1.731, m 1.738, g 1.744 (469)

Yttrium sulfate – $Y_2(SO_4)_3$ – 466.02 – Colorless – D 2.612 (469) – D.T. 1020 (470 mm.) (765)

Yttrium sulfate, hydrate – $Y_2(SO_4)_3 \cdot 8H_2O$ – 610.15 – Colorless – Monoclinic – D 2.535^{20} (423) – R.I. p 1.5433, m 1.5490, g 1.5755 (469)

Yttrium sulfide – Y_2S_2 – 274.02 – Yellow – D 3.82^{25} (552) – M.P. 1930 (in vacuum) (793)

Yttrium tantalate – $Y_2O_3 \cdot Ta_2O_5$ – 667.60 – Tetragonal – D 5.74 (X-ray) (675) (972)

Yttrium vanadate – $Y_2O_3 \cdot V_2O_5$ – 407.74 – Tetragonal – D 4.49 (139)

Zinc – Zn – 65.38 – Bluish white – Hexagonal – D 7.14^{20} (15) – M.P. 419.5 (14) (1026) – B.P. 907.2 (15)

Zinc aluminate – $ZnO \cdot Al_2O_3$ (Gahnite) – 183.32 – Colorless – Cubic – D 4.58^{11} (469) – M.P. 1950 (155) – R.I. 1.805 (319)

Zinc antimonate – $ZnO \cdot Sb_2O_5$ – 404.90 – White – Tetragonal – D 6.5 (185)

Zinc arsenate, pyro- – $2ZnO \cdot As_2O_5$ – 392.58 – D 4.701^{21} (469)

Zinc arsenate, ortho- – $3ZnO \cdot As_2O_5$ – 473.96 – White – Rhombic – D 4.913^{15} (469)

Zinc arsenate, hydrate – $3ZnO \cdot As_2O_5 \cdot 8H_2O$ (Nat. koettigite) – 618.09 – Monoclinic – D 3.309^{15} (469) – D.T. 100 (469) – R.I. p 1.662, m 1.683, g 1.717 (469)

Zinc arsenate, hydrate – $4ZnO \cdot As_2O_5 \cdot H_2O$ (Nat. adamite) – 573.36 – Colorless – Rhombic – D 4.345 (469) – M.P. $>$ 100 (469) – R.I. p 1.708, m 1.733, g 1.758 (469)

Zinc borate – $3ZnO \cdot 2B_2O_3$ – 383.42 – Colorless – M.P. 980 (761)

Zinc borate – $3ZnO \cdot 2B_2O_3$ (Glass) – 383.42 – Colorless – D 3.64 (761)

Zinc borate, fluo- – $ZnF_2 \cdot 2BF_3$ – 239.02 – R.I. p –, m > 1.36, g $= p + 0.011$ (227)

Zinc carbonate – $ZnCO_3$ (Smithsonite) – 125.39 – Colorless – Trigonal – D 4.3476^{28} (21) – D.T. 133 (760 mm.) (520) – R.I. o 1.849, e 1.621 (713)

Zinc carbonate, basic- – $2ZnCO_3 \cdot 3Zn(OH)_2$ (Nat. hydrozincite) – 549.98 – Monoclinic – D 3.7 (469) – R.I. p 1.640, m 1.736, g 1.750 (469)

Zinc chloride – $ZnCl_2$ – 136.29 – Colorless – Cubic – D 2.925^{25} (557) – M.P. 283 (521) – B.P. 732 (469) – R.I. o 1.687, e 1.713 (1075)

Zinc chromite – $ZnO \cdot Cr_2O_3$ – 233.40 – Cubic – D 5.29 (767)

Zinc chromite, thio- – $ZnS \cdot Cr_2S_3$ – 297.64 – Cubic – D 4.05 (X-ray) (725)

Zinc cobalt (III) oxide – $ZnO \cdot Co_2O_3$ – 247.26 – Cubic – D 5.94 (X-ray) (454)

Zinc columbate – $ZnO \cdot Cb_2O_5$ – 347.20 – Brown – Rhombic – D 5.69^{17} (675)

Zinc ferrite – $ZnO \cdot Fe_2O_3$ – 241.06 – Brownish red – Cubic – D 5.290 (798) – M.P. 1590 (25) – R.I. 2.31 (Li line) (798)

Zinc ferrite – $2ZnO \cdot 3Fe_2O_3$ – 641.80 – D 5.189 (432)

Zinc fluoride – ZnF_2 – 103.38 – Colorless – Monoclinic – D 4.858^{25} (91) – M.P. 872 (469) – B.P. 1500 (876)

Zinc formate – $Zn(HCO_2)_2$ – 155.42 – Colorless – D 2.268 (26)

Zinc gallate – $ZnO \cdot Ga_2O_3$ – 268.82 – White – Cubic – D 6.154 (X-ray) (159) – R.I. $>$ 1.74 (159)

Zinc germanate – $2ZnO \cdot GeO_2$ – 267.36 – D 4.823 (X-ray) (904)

Zinc hydroxide – $Zn(OH)_2$ (Stable) – 99.40 – Colorless – Rhombic – D 3.084^{21} (304) – D.T. 125 (469)

Zinc hydroxide – $Zn(OH)_2$ (Unstable) – 99.40 – Colorless – Needle – D 2.882^{18} (304)

Zinc lead antimonate – $ZnO \cdot 2PbO \cdot Sb_2O_5$ – 851.32 – Orange yellow – Anisotropic – D 7.6 (969)

Zinc lead silicate – $ZnO \cdot PbO \cdot SiO_2$ (Nat. Larsenite) – 364.65 – Rhombic – R.I. p 1.92, m 1.95, g 1.96 (760)

Zinc molybdate – $ZnO \cdot MoO_3$ – 225.33 – Colorless with yellowish tint – Tetragonal – M.P. 900 (348)

Zinc nitrate, hydrate – $Zn(NO_3)_2 \cdot H_2O$ – 207.41 – Colorless – M.P. 70.7 (266)
Zinc nitrate, hydrate – $Zn(NO_3)_2 \cdot 2H_2O$ – 225.43 – Colorless – M.P. 55.4 (266)
Zinc nitrate, hydrate – $Zn(NO_3)_2 \cdot 3H_2O$ (266) – 243.44 – Colorless – M.P. 44.07 (469)
Zinc nitrate, hydrate – $Zn(NO_3)_2 \cdot 4H_2O$ – 261.46 – Colorless – M.P. 44.7 (266)
Zinc nitrate, hydrate – $Zn(NO_3)_2 \cdot 6H_2O$ – 297.49 – Colorless – Tetragonal – D 2.065^{14} (469) – M.P. 36.1 (266)
Zinc oxalate – ZnC_2O_4 – 153.40 – D 3.28^{25} (459)
Zinc oxide – ZnO (Zincite) – 81.38 – Colorless – Hexagonal – D 5.664^{18} (863) – M.P. 1975 (153) – T.P. 570 (623) – B.P. 1723 (461) – R.I. o 2.004, e 2.020 (1075)
Zinc oxide, per-, hydrate – $2ZnO_2 \cdot H_2O$ – 212.78 – Cream white – D 3 (194)
Zinc phosphate, pyro- – $2ZnO \cdot P_2O_5$ – 304.80 – Colorless – D 3.755^{23} (189)
Zinc phosphate, ortho- – $3ZnO \cdot P_2O_5$ – 386.18 – Colorless – Rhombic – D 3.998^{15} (469) – M.P. 900 (469)
Zinc phosphate – $4ZnO \cdot P_2O_5$ – 467.56 – Rhombic – R.I. p 1.630, m 1.656, g 1.660 (1075)
Zinc phosphate, hydrate – $3ZnO \cdot P_2O_5 \cdot 4H_2O$(I) (Nat. hopeite) – 458.24 – Rhombic – D 3.04 (469) – T.P. > 105 (469) – R.I. p 1.572, m 1.591, g 1.592 (467)
Zinc phosphate, hydrate – $3ZnO \cdot P_2O_5 \cdot 4H_2O$(II) (Nat. hopeite) – 458.24 – Rhombic – D 3.03 (469) – T.P. > 140 (469) – R.I. p 1.574, m 1.582, g 1.582-1.59 (469)
Zinc phosphate, hydrate – $3ZnO \cdot P_2O_5 \cdot 4H_2O$ (Nat. parahopeite) – 458.24 – Triclinic – T.P. > 163 (469) – R.I. p 1.614, m 1.625, g 1.637 (469)
Zinc phosphate, hydrate – $3ZnO \cdot P_2O_5 \cdot 8H_2O$ – 530.31 – D 3.109^{15} (908)
Zinc phosphate, hydrate – $4ZnO \cdot P_2O_5 \cdot H_2O$ – 485.58 – Rhombic – R.I. p 1.608, m 1.624, g 1.629 (1075)
Zinc phosphate, hydrate – $4ZnO \cdot P_2O_5 \cdot H_2O$ (Nat. tarbuttite) – 485.58 – Triclinic – D 4.13 (469) – R.I. p 1.660, m 1.705, g 1.713 (469)
Zinc phosphate, hydrate – $4ZnO \cdot P_2O_5 \cdot 4H_2O$ (Nat. spencerite) – 512.29 – Monoclinic – D 3.14 (469) – D.T. 100 (469) – R.I. p 1.586, m 1.602, g 1.608 (469)
Zinc selenate, hydrate – $ZnSeO_4 \cdot 5H_2O$ – 298.42 – Trigonal – D 2.591 (469) – D.T. > 50 (469)
Zinc selenate, hydrate – $ZnSeO_4 \cdot 6H_2O$ – 316.44 – Tetragonal – D 2.325 (469) – R.I. o 1.5291, e 1.5039 (469)
Zinc selenide – ZnSe – 144.34 – Yellowish red – Cubic and hexagonal – D 5.42^{15} (469) – M.P. > 1100 (181) – R.I. 2.89 (469)
Zinc silicate – $ZnO \cdot SiO_2$ (Not found by Bunting (153)) – 141.44 – Colorless – Hexagonal or rhombic – D 3.52 (469) – M.P. 1437 (Incong.) (469) – R.I. p 1.616, m –, g 1.623 (483)
Zinc silicate – $ZnO \cdot SiO_2$ (Glass) – 141.44 – Colorless – D 3.86 (960) – R.I. 1.650 (485)
Zinc silicate – $2ZnO \cdot SiO_2$ (Willemite) – 222.82 – Colorless – Tetragonal or hexagonal – D 4.103^{25} (89) – M.P. 1512 (153) – R.I. o 1.692, e 1.720 (153)
Zinc silicate – $2ZnO \cdot SiO_2$ (Glass) – 222.82 – Colorless – D 3.850 (95)
Zinc silicate, hydrate – $2ZnO \cdot SiO_2 \cdot H_2O$ (Nat. hemimorphite) – 240.84 – Trigonal or rhombic – D 3.45 (469) – R.I. p 1.614, m 1.617, g 1.636 (469)
Zinc silicate, fluo-, hydrate – $ZnSiF_6 \cdot 6H_2O$ – 315.54 – Colorless – Hexagonal – D 2.12 (385) – R.I. o 1.3824, e 1.3956 (348)
Zinc sulfate – $ZnSO_4$ – 161.44 – Colorless – Rhombic – D 3.74^{15} (469) – T.P. 740 (307) – D.T. 840 (467) – R.I. p 1.658, m 1.669, g 1.670 (469)
Zinc sulfate, hydrate – $ZnSO_4 \cdot H_2O$ – 179.46 – D 3.195^{25} (933) – D.T. 238 (469)
Zinc sulfate, hydrate – $ZnSO_4 \cdot 6H_2O$ – 269.54 – Colorless – Monoclinic (tetragonal) – D 2.072^{15} (469) – — $5H_2O$ at 60° (204)
Zinc sulfate, hydrate – $ZnSO_4 \cdot 7H_2O$ (Goslarite) – 287.55 – Colorless – Rhombic – D 1.957^{25} (933) – T.P. 39 (469) – D.T 280 (469) – R.I. p 1.4620, m 1.4860, g 1.4897 (469)
Zinc sulfate, hydrate – $ZnSO_4 \cdot 7H_2O$ – 287.55 – Colorless – Monoclinic – R.I. p 1.4567, m 1.4800, g 1.4840 (797)
Zinc sulfide – ZnS(I) (Wurtzite) – 97.44 – Hexagonal – D 4.087 (469) – M.P. 1645 (under pressure) (521) – S.P. 1185 (469) – R.I. o 2.356, e 2.378 (469)
Zinc sulfide – ZnS(II) (Sphalerite) – 97.44 – Cubic – D 4.102^{25} (469) – Transition to I at 1020 (469) – R.I. 2.3682 (469)
Zinc telluride – ZnTe – 192.99 – Red – Cubic – D 5.54^{18} (469) – M.P. 1238.5 (469) – R.I. 3.56 (469)
Zinc tin (IV) oxide – $2ZnO \cdot SnO_2$ – 313.46 – Colorless – Cubic – D 6.39 (X-ray) (986)
Zinc titanate – $ZnO \cdot TiO_2$ – 161.28 – Pale violet – Needle – D 3.17^{20} (469)
Zinc titanate – $ZnO \cdot 3TiO_2$ – 321.08 – Violet – D 4.92^{15} (469)
Zinc titanate – $2ZnO \cdot TiO_2$ – 242.66 – Black – D 5.12 (201)

Zinc titanate – $3ZnO \cdot 2TiO_2$ – 403.94 – Yellow – D 3.83 (469)
Zinc titanate – $4ZnO \cdot 5TiO_2$ – 725.02 – Pale brown – Small leaflets – D 3.68^{19} (469)
Zinc tungstate – $ZnO \cdot WO_3$ – 313.30 – Colorless – Monoclinic – D 7.79 (X-ray) (348)
Zirconium – Zr – 91.22 – Silvery gray – Hexagonal – D 6.4^{20} (15) – M.P. 1750 (14) (1026) – B.P. 5050 (15)
Zirconium chloride – $ZrCl_4$ – 233.05 – Colorless – D 2.803 (1030) – M.P. 437 (25 atm.) (817) – S.P. 331 (817)
Zirconium columbate – $ZrO_2 \cdot 5Cb_2O_5$ – 1452.32 – Acicular – D 5.14^{17} (675)
Zirconium fluoride – ZrF_4 – 167.22 – Colorless – Monoclinic – D 4.54^{25} (425) – B.P. Red heat (873) – R.I. p 1.57, m 1.60, g – (425)
Zirconium nitrate – $Zr(NO_3)_4$ – 248.03 – R.I. o 1.60, e 1.61 (976)
Zirconium oxide – ZrO_2(I) – 123.22 – Rhombic, cubic or trigonal – D 6.27 (X-ray) (769) – M.P. 2715 (521) (1119) – Undercooled transition 625 (198)
Zirconium oxide – ZrO_2(II) – 123.22 – Tetragonal – D 6.10 (198) – Transition to I 1900 (198)
Zirconium oxide – ZrO_2(III) (Baddeleyite) – 123.22 – Slight yellow or colorless – Monoclinic – D 5.56 (198) – Transition to II 1000 (198) – R.I. p 2.13, m 2.19, g 2.20 (469)
Zirconium phosphate – $ZrO \cdot P_2O_5$ – 265.18 – Cubic – D 3.195 (639)
Zirconium silicate – $ZrO_2 \cdot SiO_2$ (Zircon) – 183.28 – Colorless – Tetragonal and two other modifications – D 4.15, 4.32, 4.7 (181 a) – M.P. 2430 (1120) – R.I. o 1.923-1.960, e 1.966-2.015 (469)
Zirconium silicate – $ZrO_2 \cdot SiO_2$ (Glass) – 183.28 – Colorless – R.I. $\sim$ 1.46 (1120)
Zirconium sulfate – $Zr(SO_4)_2$ – 283.34 – Colorless – D 3.22^{16} (53)
Zirconium sulfide – ZrS_2 – 155.34 – Cinnamon brown – Hexagonal – D 3.87 (791)
Zirconium sulfide oxide – ZrSO – 139.28 – Light yellow – D 4.87 (469)

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THE PROBLEM OF CHANGING FOOD HABITS

REPORT OF THE COMMITTEE ON FOOD HABITS
1941–1943

CARL E. GUTHE, *Chairman*
MARGARET MEAD, *Executive Secretary*

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PREFACE

With the fall of France it became apparent to the American people that a program of national defense, leading if necessary to participation in the war, was imperative if our freedom and democratic way of life was to be preserved. In keeping with this development, President Roosevelt invoked the National Defense Act of 1916 and set up on May 29, 1940, the National Defense Advisory Commission. Miss Harriet Elliott was appointed a member of this Commission in charge of the interest of consumers and the welfare of civilians in our defense programs.

Miss Elliott recognized that in the light of present day science, human nutrition and problems related to the health side of food were among the more important elements in civilian defense. Shortly after the organization of the Defense Commission, Miss Elliott did me the honor of asking me to assist her in the formation of a nutrition program in relation to national defense activities. In a preliminary report to Miss Elliott, emphasis was placed on two aspects: first, the mobilization and use of existing science as a scientific policy foundation for action programs; second, the utilization of existing agencies through coordination of effort rather than the setting up of new agencies.

A plan for mobilizing science for defense and war effort was already in existence in the National Research Council. In discussing these matters with Miss Elliott, we held that the goal—diets that would give each individual his daily biochemical nutrition requirements—was not only a matter of biochemistry and physiology but of food habits as well.

Biological science may advance ever so far, but unless we as individuals adjust our food habits to changing biochemical knowledge little happens. Therefore the National Research Council was asked to set up two committees of equal standing, one dealing with the biochemical and physiological side of nutrition, the other dealing with the psychological and cultural pattern—a Committee on Food Habits.

Both committees have rendered great service to the defense and war food and nutrition program. For at least a third of a century biochemical and physiological research have been directed toward human nutrition and consequently there is now a large body of scientific knowledge which can be drawn upon. However, in the social science field but little had been done in the sciences dealing with culture, behavior, and personal traits in relation to food habits. Therefore, to a degree, the Committee on Food Habits has had a pioneer job.

The Committee on Food Habits was asked to draw together existing knowledge bearing on food likes and dislikes and the processes of their formulation and change. It was asked to stimulate research in the social sciences in these fields. The Committee was requested to be prepared to give the advice and judgment of social science from the several disciplines, particularly psychology and cultural anthropology, with reference to requests made to it by the Nutrition Division of the Office of Defense Health and Welfare Services (whose activities have now been transferred to the War Food Administration, Nutrition and Food Conservation Branch) and with reference to requests made to it by the various federal agencies with membership in the Federal Interdepartmental Nutrition Coordinating Committee and the State and local nutrition committees when communicated through the proper channels.

In my judgment, the Committee on Food Habits has fulfilled its responsibility, and carried out in a most outstanding manner what was expected of it when the original plans were made. The summary of its activities, as contained in this report, is ample evidence for the above statement. The first stage of the pioneer period is over. A new science of food habits is developing. This will be a handmaid to, and of equal importance with, the biochemical science of nutrition in efforts for the prevention of disease and facilitating man's progress toward optimum health. The Committee on Food Habits with the understanding guidance of its chairman, Dr. Carl S. Guthe, and with Dr. Margaret Mead, its efficient and imaginative executive secretary, are to be congratulated for their great contribution to the wartime nutrition program.

M. L. WILSON, Chief
Nutrition and Food Conservation Branch
Food Distribution Administration
War Food Administration

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PART I

INTRODUCTION

HISTORY OF THE COMMITTEE ON FOOD HABITS

CARL E. GUTHE

The story of the Committee on Food Habits of the National Research Council is one which relates an incident in the government defense program that reflects the foresight and vision of certain government officials, and demonstrates the efforts made by scientists to pool their knowledge and experience within a restricted subject for the benefit of the government agencies requesting their assistance and advice.

Late in November of 1940, well over a year prior to the Pearl Harbor incident, officials of the National Research Council, at the request of the National Defense Advisory Commission, undertook a series of conversations with Dr. M. L. Wilson, of the Department of Agriculture, who was also chairman of the Federal Interdepartmental Nutrition Coordinating Committee, concerning ways and means by which the National Research Council could aid in studying problems of nutrition. Dr. Wilson pointed out that one aspect of national defense was concerned with the physical fitness of the entire population of our country. Nutrition, of course, must play an important part in this problem. It was known that an appreciable portion of the population suffered from malnutrition. The questions immediately arose as to what could be done to improve the nutritional status of the population and as to how this could be accomplished on the basis of the best scientific judgment, derived not only from our knowledge of the scientific facts of nutrition, but also from the technical study and interpretation of the sociocultural factors affecting the food folkways throughout the nation.

As a result of these negotiations, the National Research Council, early in December of 1940, established two interdivisional committees in the life sciences on which the chairmen of the Divisions of the Medical Sciences, of Biology and Agriculture, and of Anthropology and Psychology, are *ex officio* members. One of the committees was the Committee on Food Habits, which was assigned for administrative purposes to the Division of Anthropology and Psychology. The other sister-committee was the Committee on Food and Nutrition, which later became known as the Food and Nutrition Board, and which was assigned for administrative purposes to the Division of Biology and Agriculture.

The first meeting of the Committee on Food Habits was held on January 3 and 4, 1941. Dr. John M. Cooper, of the Catholic University of America, had accepted the chairmanship of the Committee. During the spring, members of this Committee were in two groups: scientists not connected with the government, whose special interests and experience related to the Committee's objectives, and experts in government service who were concerned in one way or another with problems relating to the food situation in this country. The members of the Committee at this time were as follows:

Non-governmental Members

John M. Cooper, Chairman
Ruth Benedict
Paul Cornell
Allison Davis
Helen S. Mitchell
Curt P. Richter
George D. Stoddard
Mary E. Sweeny
William Lloyd Warner

Liaison Members from the Federal Government

Martha Eliot
Paul E. Howe
Rensis Likert
Carroll E. Palmer
John S. Provinse
W. H. Sebrell
Hazel K. Stiebeling
Ruth S. Tolman

The immediate task which confronted the Committee was that of formulating a plan of action. Following two meetings and some correspondence, a program was established under date of February 28. The introductory paragraph to this statement follows:

"In appointing a Committee on Food Habits in addition to the Committee on Food and Nutrition, the National Research Council has acted on the assumption that, while the first step toward achieving an adequate national nutritional level is the securing of scientific information on what constitutes proper diets, there remains the second step, requiring an equally scientific approach, of finding the most effective ways and means of adjusting habits to needs, of getting people to wish what they need. This Committee, in undertaking its assignment, agrees wholeheartedly with this point of view and feels that governmental agencies as well have a similar twofold responsibility."

The program was provisional in the sense that it was based upon the knowledge and assembled data then available to the Committee members. The Committee, of course, planned to continue to gather, coordinate, and appraise the existing and scattered data and to promote, in so far as possible, a limited number of research projects.

This provisional program of action was divided into four sections, formulated in the form of questions:

"The recommended practical program of action is broken down into the following sections. First, where are the major weaknesses and deficiencies in our national dietary habits, and who therefore need most to be reached in either a short-range or long-range campaign? Second, what major causes are responsible for such weaknesses and deficiencies, and what should be gotten to the poor-diet groups to enable them to bring their dietary habits into conformity with dietary needs? Third, who are best equipped for undertaking the task of reaching the poor-diet groups? Fourth, by what procedures and media can such groups be most effectively reached?"

After considering the first question, the Committee recommended:

"1. That the whole population of the United States be reached with, however, particular attention to:
  "a. The low income non-farm groups, largely concentrated in the eastern Industrial Belt;
  "b. The low income groups of the Southeast, including especially the farm and negro population thereof.
"2. That regional and state agencies devote special attention to those racial, national, and cultural groups in isolated areas, whose diets may be or are known to be deficient.
"3. That every effort be made to reach adequately the women, especially mothers and wives."

In considering the second question, the Committee came to the conclusion that it "should advocate diets that are believed to be satisfactory, developing methods suitable for all levels of the population; the understanding being that other agencies will consider the means of economic production and distribution, while this Committee concentrates upon the diffusion of knowledge and the improvement of food habits." It further stated that: "To be successful, the nutrition educational campaign must achieve the following: a) create interest in nutrition; b) educate people to know and wish the necessary changes in their diet; c) produce these changes and establish them as habits; d) firmly establish these adequate habits in the culture as food folkways. To stop short of d), especially at a) or b), will mean that the program will fail, because the people will almost certainly lapse into their old food habits. While, therefore, a short-time intensive emergency educational campaign is desirable and can accomplish much, long-range educational work will also have definitely to be planned for."

In answering the third question, the Committee made the following statements: "So far as possible, already existing and functioning organized groups and agencies, public and private, should undertake or take part in the execution of the nutrition education program. . . . . While it is highly desirable in a national campaign to make full use of technically trained individuals and organized groups in the field of nutrition at the local, state, and national level, and while they should guide and advise, it seems undesirable, especially at the local level, for them to have exclusive management of the educational program. . . . . It is of paramount importance to secure as full and democratic participation as possible on the part of the leaders and general membership of the organizations of women. On the women, more than on anyone else, depends, in the short run and in the long run, the family's diet, both as to choice of food and as to preparation thereof. But the man should not be left out of the picture, even at the local level, as the men too have a voice, and sometimes the deciding voice, in choice and preparation of the family food."

In dealing with the fourth question, the Committee recommended that the fullest possible use be made of leaflets, booklets, posters, and nutrition films, and that the program of the National Nutrition Education Campaign "be tried out experimentally in selected test localities before being put into operation on a nationwide scale."

The essential points of this provisional program of action have been incorporated in this statement, because they reveal most adequately the attitude of mind of the Committee during the first months of its existence, and form a frame of reference or charter which tended to control the subsequent activities of the Committee during the coming two years. About this time two sub-committees were created to investigate the potential activities which might be undertaken in two special fields. One was the Subcommittee on Changing Children's Food Habits, of which Miss Mary Sweeny was chairman, and the other the Subcommittee on Publicity, of which Dr. W. H. Sebrell was chairman.

Unfortunately, about April 1, 1941, the severe illness of Dr. Cooper forced him to abandon the active leadership of the Committee. Within a few weeks the Committee was fortunate in securing the services of Dr. Rensis Likert, of the Department of Agriculture, as acting chairman, a post which he held until the close of the fiscal year on June 30, when he became seriously ill and unable to direct the affairs of the Committee during the summer months of 1941. The latter part of the spring of 1941 was devoted largely to exploratory activities. Close contact was maintained with Dr. Wilson's office in the office of the Hon. Paul McNutt, Coordinator of Health, Welfare, and Related Defense Activities. Preliminary arrangements were made toward formulating a series of research projects for the Committee and toward securing governmental support for the work of the Committee during the coming fiscal year of 1941-42. It became increasingly evident that a large number of civilian and government organizations were actively interested in various socio-cultural aspects of the nutrition problem. The Committee needed to familiarize itself with many of these activities. Therefore, under the leadership of Dr. Likert, two conferences * were held late in the spring.

The first of these conferences was held in Washington on May 23 and 24, immediately preceding the National Nutrition Conference called by President Roosevelt. These two days were devoted to brief reports from 15 individuals upon a variety of investigations into the problems of food habits conducted throughout the country by several colleges, universities, and research centers, as well as by some of the government departments, such as the Department of Agriculture, the Office of Education, and the Bureau of Indian Affairs. In choosing the participants, special consideration was given to studies being conducted in the southern and southeastern part of the country, since this area seemed to be of special significance from the nutritional standpoint.

The second conference also occupied two days, and was held a month later on June 27 and 28. On the first day reports from the field of market research were given by representatives of the American Meat Institute,

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* See Summaries of a Conference on "Research in the Field of Food Habits," May 23-24, 1941, a Conference on "Contributions from the Field of Market Research," June 27, 1941, and a Conference on "Contributions from the Field of Child Development," June 28, 1941, pp. 127, 141, and 149 of this report.

the Evaporated Milk Association, and the National Livestock and Meat Board. The second day was given over to reports from nine individuals representing various research centers which had been carrying on investigations into children's food habits, and to statements by six persons upon studies of educational programs and their orientation made by government and civilian groups.

These informative conferences performed several functions. First, they demonstrated the need for giving due consideration to the psychological and socio-cultural factors which are involved in carrying out any national nutrition campaign. Second, they offered the participants an opportunity to exchange ideas and familiarize themselves in more detail with the work done by their colleagues in other institutions. Third, they furnished the members of the Committee factual data upon the great variety of subjects for study in the field of food habits, and the diversity of methods used in their investigation.

At the closed meeting of the Committee, held on June 29, immediately following the second of the large conferences, which Dr. Likert as acting chairman was unable to attend because of illness, considerable time was given to a discussion of a number of proposals for investigations and studies to be undertaken under the auspices of the Committee. These varied considerably in objectives and in methods, and some would have required considerable sums for their prosecution. A few were approved tentatively subject to securing the necessary funds. Among these was one suggested by Miss Genoeffa Nizzardini, calling for a study of the food habits of minority nationality groups in this country, beginning with the Italian group.

The reports of the two subcommittees led to an extended discussion of the potential relationship between the Committee on Food Habits and the government organizations it sought to serve. This resulted in the following resolution:

"Regarding itself as a committee of the National Research Council established to give aid, by means of advice and research, in improving the food habits of the American people at a time of national emergency, the Committee on Food Habits recommends:

"a. That it reaffirm its early unanimous action calling for the mobilization of such resources as will make the necessary foods available and will unite existing federal, state, and private agencies in the promotion of an effective plan for improving food habits;

"b. That it be informed of the governmental personnel and program set up to implement the improvement of food habits in order that the Food Habits Committee may be guided in its advisory and research functions, for example in recommending surveys of present conditions, the evaluation of proposed undertakings, and measures of the effectiveness of programs;

"c. That its action calling for the evaluation of educational programs and related researches be recognized by adequate actions and appropriations within the designated governmental agency;

—all with the understanding that the total nutritional program shall be conceived consistently with the nation-wide scope of the problem, and with a further understanding that the Food Habits Committee shall continue to function, not in administrative action, but in consultation and research recommendation."

Because of the illness of both Dr. Cooper and Dr. Likert, it was necessary for the Committee to consider the matter of another chairman. In the discussion, it was recognized that the potential usefulness of the Committee could not be approximated by depending solely upon the spare time of the Committee members, who without exception have obligations to their respective institutions and organizations. The suggestion was made at this meeting that the Committee attempt to secure either a full time chairman or a full time executive secretary to work toward the objectives for which the Committee was created.

During the first six months of 1941, which constituted the formative stage in the Committee's existence, a considerable amount of progress had been made. A program of action had been established. Studies had been made and conferences held as means of exploring the fields of interest of the Committee. Through its deliberations, the Committee succeeded in pointing out the importance of recognition of the variable food habits of the people of our nation, and the significance of the variety of problems connected therewith. However, the Committee was not yet fully integrated, nor was its status in the nutrition program of the national defense organizations clearly defined.

During the summer of 1941 the work of the Committee progressed slowly, due to the unavoidable lack of active leadership and the equally unavoidable delay in the appointment of a new chairman. However, the work upon the study of the food habits of the Italians in this country was carried forward by Miss Nizzardini. In addition, an important step was taken concerning the future of the Committee. During the summer the National Academy of Sciences signed a contract with the office of the Coordinator of Health, Welfare and Related Defense Activities in the Federal Security Agency, covering the financial support by the latter of the work of the Committee on Food Habits and the Food and Nutrition Board of the National Research Council, for the fiscal year 1941-42. The Academy, acting for the National Research Council, agreed to use this sum "to conduct studies and investigations and prepare reports, with the aid of technical experts, utilizing committees and subcommittees and other facilities available, upon: food, nutrition, and food habits," and "to keep the coordinator informed by means of such reports and other communications or advice as the coordinator may need or request, in regard to the progress of the studies or other activities which it may undertake in accordance with this contract."

In October, Dr. Carl E. Guthe, of the University of Michigan, accepted the chairmanship of the Committee, and undertook its reorganization and the redefinition of its policies. On November 3, the members of the Committee residing in the Washington area were called together to discuss the plans of the chairman. In November, the chairman issued a memorandum based upon the principles expressed in the provisional program of action adopted by the

Committee the previous spring. In preparing this memorandum he took into account the nature of the contract signed during the summer and information he had secured in the early fall while attending a meeting of the National Advisory Committee on Nutrition. This memorandum, looking toward the redefinition of the Committee's policies, contained the following statements:

"The government agencies, working through a coordinating committee, have taken the responsibility for studying, through surveys and field work, the varieties, the distribution, and the extent of dietary practices in the nation, and for the organization of various campaigns looking toward the influencing of public opinion upon nutritional subjects.

"The Food and Nutrition Board of the Division of Biology and Agriculture has taken the responsibility for studying the nutritional values of the elements of diet, and for making recommendations upon various foods and food elements in terms of nutritional needs.

"The Committee on Food Habits . . . . should supplement rather than duplicate the activities of these other agencies. . . . . It should concentrate upon folkways and not upon diet and nutrition, in order to prepare itself to assume the responsibility of making recommendations upon the use or misuse of the forces which affect changes in food habits.

"Phenomena of cultural change have been studied in several disciplines, from different viewpoints, and with varying results. Students of biology, physiology, psychology, anthropology, sociology, public relations, public health, and education have all given attention to these phenomena, have accumulated data and formulated various correlations, deductions, and conclusions, which are being transmitted in the academic and scientific world to other students through the media of teaching and publications.

"The membership of the Committee has been chosen in terms of breadth of viewpoint and of experience in the several disciplines concerned. The Committee faces an unusual challenge. The opportunity exists to play an important part in the improvement of national health through nutrition. The opportunity is offered to demonstrate that students of culture are able to furnish practical advice upon current problems in our own culture.

"The Committee on Food Habits should assume the responsibility of making scientifically sound recommendations to the appropriate governmental agencies upon the characteristics of the variety of food habits throughout our nation, and upon the methods of controlling the cultural forces which cause them to change."

The reorganization recommended by the chairman involved three changes of policy. In the first place, it was strongly urged that a full time paid executive secretary be employed and placed in charge of a Washington office of the Committee. In the second place, it was recommended that the Committee proper, later known as the Executive Members of the Committee, consist only of scientists and scholars interested in food habits who are not connected with the government service. In the third place, it was recommended that liaison members of the Committee be officially appointed by the proper authorities in each of the Government agencies potentially interested in the work of the Committee, and that these liaison members act, not as Committee members, but as liaison advisors to the executive secretary in maintaining continuous and informal contact between the Committee and the several government agencies represented.

The executive membership of the newly organized Committee was as follows, representing the fields of anthropology, psychology, sociology, home economics, physiological psychology, and public health:

Ruth Benedict
John M. Cooper
Allison Davis
Joseph K. Folsom
Lawrence K. Frank
Carl E. Guthe, chairman
Mark A. May
Curt P. Richter
Nathan Sinai
Mary E. Sweeny
W. Lloyd Warner

From this time on, the membership of the Committee has remained constant with the single exception of the resignation of Dr. Curt Richter in the summer of 1942. He was replaced by Dr. Warren T. Vaughan, who brought to the Committee a knowledge of the medical sciences.

At a meeting of the reorganized Committee on December 6, 1941, the recommendations of the chairman were approved and he was authorized to invite Dr. Margaret Mead to become executive secretary and take charge of the office in Washington. The Committee further agreed that objectives were twofold: first, to analyze and interpret existing technical knowledge upon the methods and principles of the several disciplines represented by its membership in such a way that this technical knowledge may be applied specifically to the field of food habits, and second, to establish research projects which will furnish information upon methods and principles applicable to the field of food habits, concerning which the Committee does not now possess sufficient knowledge.

Dr. Margaret Mead, to the great good fortune of the Committee, accepted the post of executive secretary, at first on a part time, non-resident basis for the month of January, 1942. On February 1, having been granted a wartime leave of absence from the American Museum of Natural History, she came to Washington to take charge of the office of the Committee on a full time basis.

At a meeting of the Committee held on February 14 and 15, 1942, Dr. Mead presented a series of plans for investigations based upon the principle of decentralizing research and thereby using the facilities of many colleagues in various parts of the country. The several recommendations of the executive secretary which were approved by the Committee at this meeting were:

a. Plan for organizing qualitative opinion sampling squads among social science students on a volunteer basis, particularly in non-land-grant colleges.
b. Plan for the coordination of local research at several research centers with the active cooperation of members of the Committee whenever possible.

c. Plan for utilization of secondary sources and using experts as informants.
d. Plan for coordination of local universities and colleges with ongoing community experiments in nutrition campaigns.
e. Plan for developing a standard series of research leads.

All of these proposals had value from at least two standpoints. They made it possible for the Committee to secure rapidly and with little expense definitive information from various parts of the country upon current attitudes toward nutrition and existing food habits. They also enabled the Committee to keep in touch with experts in all parts of the country and thereby represent more adequately in its relations with the various government agencies the opinion of these scholars and scientists.

The results obtained since February 1942, in carrying out this research program are dealt with elsewhere in this volume. It is sufficient to indicate here that most of these plans were carried out and expanded as opportunity offered, thereby bringing to the Committee a quantity of information which has enabled it to issue at various times mimeographed reports upon the results of the use of these several research mechanisms.

In the Washington office, Dr. Mead was given the services of two technical assistants to collate and analyze the research data received by the office from these several sources. During the spring of 1942, Dr. Mead established contact and liaison relations with seventeen government agencies actively concerned with the nutrition program through Dr. Wilson in the Office of Defense Health and Welfare Services of the Federal Security Agency. Dr. Mead has maintained a useful and efficient relationship with all interested government agencies, thereby meeting most satisfactorily one of the objectives of the Committee.

During the spring of 1942, a program was inaugurated by which at each meeting of the Executive Members of the Committee, at least one half day was devoted to a liaison session, to which were invited all of the Liaison Members of the Committee and any other guests who would be interested in the proceedings. These liaison sessions * were devoted to informal discussions of matters of current interest in the nutrition campaign, thereby enabling the Executive Members of the Committee and the Liaison Members to become acquainted and to exchange knowledge of their activities and points of view. The sessions were usually constructed around a series of reports by specially invited guests.

In the course of the development of the work of the Committee, Dr. Mead found opportunity, frequently at the suggestion of Dr. Wilson, to undertake trips to various parts of the country in order to evaluate at first hand local conditions affecting food habits and to consult directly with colleagues who had undertaken various research projects under the auspices of the Committee.

In the summer of 1942, the contract between the National Academy of Sciences and the Federal Security Agency was renewed for the fiscal year

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* See summaries of proceedings of Liaison Sessions of the Committee on Food Habits, pp. 158, 159, 160, and 162 of this report.

1942-43, but this time without any provision for research funds such as had been contained in the previous contract. This required the Committee to seek additional research funds from non-governmental sources. Such a program, which had already started in the spring of 1942, was carried forward successfully and several additional research projects were established under funds granted by several non-governmental agencies.

With the entry of the United States into the war, the interests and objectives of the nutrition campaign have, of course, been changed to some extent. Correspondingly, the Committee has become more interested in problems of food habits which relate to the rationing of food in this country and to the distribution of foods to various parts of the world under the lend-lease program. In connection with these interests, the Committee has tended to broaden its association with government agencies through contacts which the executive secretary has made with the Office of Foreign Relief and Rehabilitation Operations and the Office of War Information.

It is evident, as the fiscal year 1942-43 draws to a close, that the work of the Committee has expanded and become increasingly complex. Yet its achievements are all closely related and in their entirety constitute an integrated approach to the factual problems of definition and description of dietary patterns, to the psychological problems involved in the individual conformity or non-conformity to cultural norms, and to the applied science problems of bringing traditional dietary patterns into conformity with the findings of the science of nutrition. The technical details included in the reports and releases which have been issued demonstrate the complementary nature of the work of the Committee to that of the Food and Nutrition Board. The studies and investigations being conducted by the Committee on Food Habits furnish the necessary data and constitute the technical basis for the immediate and useful services it is now rendering the wartime food program.

This statement, taken from the chairman's most recent annual report, constitutes a summary of the principles which have governed the work of the Committee during the second phase of its existence which began with the employment of Dr. Mead as executive secretary in January of 1942. The fundamental guiding policy is still the same as that laid down in the provisional program of action adopted by the Committee in the spring of 1941. The work which has been done has clarified and made specific the methods used and the results obtained through attempting to answer the four questions around which this original program of action was formulated.

During the spring of 1943, reorganization within the Federal Government transferred the nutrition program from the Federal Security Agency to the United States Department of Agriculture. However, this change in administration did not affect the Committee or its relationship to the nutrition program, which now operates under the Nutrition and Food Conservation Branch of the Food Distribution Administration. The function of the Committee has become satisfactorily clear, both as an advisory body to the nutrition program of the Federal Government and as one of the interdivisional committees in the life sciences of the National Research Council.

Within itself, the Committee on Food Habits has become integrated and has grown into a closely knit, smoothly functioning group of scientists who have contributed generously and without reservation their technical knowledge and experience to the discussion and the attempted solution of the problems presented to the Committee.

The story of the Committee on Food Habits records a reasonably successful attempt on the part of a body of scientists chosen from several disciplines to work together for the purpose of aiding government officials with vision in their desire to take advantage of scientific knowledge in furthering the interests of the people of our country.

THE PROBLEM OF CHANGING FOOD HABITS

Margaret Mead

Problems of changing food habits cut across ordinary discipline lines, in addition to involving contributions from both pure and applied sciences. There is a mass of literature and recorded experimentation on many aspects of the problem, ranging from studies of soil agronomy which illuminate the question of whether the habit of eating locally grown food is or is not the most nutritionally valuable behavior, through data on the content of diets, data on the relationship between purchasing power and diet, studies of historically changing diets, animal experiments in individual taste and preference and their relation to nutrition, and records of the cultural integration of food through case histories of individuals whose gastrointestinal disorders can be shown to be systematically related to the way in which learning to eat was combined with other types of learning.

As the Committee's task was to integrate existing materials and devise new ways of tapping existing knowledge on the problem of cultural change, a primary requirement was to develop a point of view, an approach which could make systematic use of additions to knowledge in all of the fields from which research results could be expected. New information is continually coming out on the perishable quality of vitamins in vegetables on a steam table; on a new experiment in a rat's preference for the food which he ate less often regardless of whether it was a more or less nutritious food; on the relative palatability of different varieties of the same food; or, on the other hand, on detailed studies of purchasing habits of subcultural groups, or of striking shifts in the consumption of different foods under various sorts of pressure (advertising, wartime shortages, etc.); on new experiments in the relationship between anxiety and acidity in the stomach. All of these findings have to be fitted together to provide a systematic and coherent scientific background for recommendations directed toward changing the dietary pattern of American culture.

Furthermore these findings have to be examined also to provide orientation for the Committee's responsible task of estimating clearly the relationship between any particular change which may be introduced in the dietary patterns, or the culturally standardized methods of inculcating food habits, and the impact of such a change on other parts of our culture or the culture of other peoples of the world with whom we come into contact through lend-lease, relief and rehabilitation procedures. For example, an increased knowledge of nutrition which is acquired by mothers without any concordant alterations in their methods of child training may produce feeding problems which have a far more serious effect upon the child's development than the less perfect diet which the child ate without pressure. Gifts of relief white flour, while temporarily stemming famine, may fasten upon a population which traditionally ate whole grains a habit with disastrous repercussions for their future health. The way in which substitutions necessitated by war are presented to the public may have later effects on the acceptance of those foods. Authoritarian methods used in enforcing nutritional standards may endanger democratic participation in other community activities. Alterations in the source of the food, as when individual food tickets are given to children in emergency mass feeding situations, may result in a breakdown of parental authority which was primarily sanctioned by the food-giving functions of the family. Only by putting each recommended innovation and the methods suggested for bringing it about against the total cultural picture, is it possible to guard against initiating changes which, while nutritionally desirable in the narrow sense, may be socially undesirable in a wider sense.

The principal discipline represented among the Committee members is cultural anthropology, and the conceptions of cultural anthropology have been used in developing the approach. Food habits are seen as the culturally standardized set of behaviors in regard to food manifested by individuals who have been reared within a given cultural tradition. These behaviors are seen as systematically interrelated with other standardized behaviors in the same culture. In attempting to estimate the strength of any given item of behavior, e.g., preference for meat, aversion to milk, etc., this item is not treated as isolated, but is referred to the total complex of behaviors which constitute the food habits. Similarly, in considering methods of change, of innovation or alteration in existing patterns, recourse is had not merely to traditional psychological pronouncements on learning, but also to the habits of learning of Americans in 1943, and furthermore to learnings or resistances which involve the body as directly as do habits connected with food. Moreover, the interaction between the culturated individual and his environment has two aspects in any consideration of food habits, interaction with the food producing and food distributing systems, that is, adjustments to the physical environments, and interaction between the individual organism and the actual food. While cultural factors are expected to account in very large degree for the food habits of mankind, there is also the possibility that combinations of foods may exert a certain degree of coercion upon physiological responses, so that the constitution of foods themselves must also be taken into account.

A dynamic description of the total food habits pattern of a culture or subculture can be approached in a number of different ways. A minute survey of the food eaten at any given time by adults may be combined with careful observations and experimentally instituted attempts to change that pattern. For example, if we had a complete picture of the current eating habits of the members of an upstate New York community, adequate verbal accounts of the grounds upon which they rationalized their current procedures, and records of attempts to introduce new foods and alter both their meal pattern and the combinations in which foods were habitually eaten, together with verbatim records of acceptances and refusals and reasons given, it would be possible to construct an adequate description of the contemporary pattern, not only its overt content but also its deeper emotional content, of the terms in which the people of that community seek and accept food, the fears and repugnance which deter them from eating other food, the situations in which they will share food, or accept food differently prepared or served, and of the states of mind which might result from any drastic alteration in their traditional food habits.

Another approach to the dynamics of the food complex is to study the ways in which, within any given culture, good habits are inculcated in the growing child. Such an approach involves descriptions of the post partum procedures, breast feeding, supplementary feeding, weaning techniques, sanctions invoked to narrow the child's acceptance within socially approved limits, sanctions invoked to widen the child's acceptance to include all socially prescribed foods, and ways in which gifts of food, threats of deprivation of food, and situations involving food are integrated in the system of character formation. On the basis of such analysis, it would be possible to prescribe the lines which would have to be followed if effective change were to occur, and the implications of changed food habits for the rest of the personality.

Neither type of study is yet available in any complete form. During the last two years two field expeditions, one consisting of seven field workers under the auspices of the University of Chicago,[*] and one of two field workers under the auspices of the Nutrition Division [†] of the Office of Defense Health and Welfare Services, have made preliminary studies of this kind which provide us with the most extensive body of data yet collected on intensively observed small communities in a modern culture. Neither study approximates the sort of completeness which can be obtained on a primitive society. Preliminary memoranda have been prepared, using living primary sources, on the culturally differentiated food habits of certain subcultural groups in the United States.[1, 13, 14, 28, 29]

As there was no immediate prospect of financing intensive cultural studies of American food habits, it was decided to devise a flexible instrument by which a quick appraisal of some of the more significant motivations could be arrived at. Professor Kurt Lewin,[‡] [15] of the State University of Iowa, developed a test based upon intensive interviewing, which he tested out upon some 2300 school children in Cedar Rapids, Iowa. This test can be used rapidly with groups of school children in any area and brings into relief such dynamic relationships as the degree of association between food which is disliked and food which is healthy; which types of food are presided over by the mother, the father, contemporaries, teachers, and health authorities; how food behavior is expected to change with increasing maturity and independence, etc.

A related instrument which can be used in defining the content and pattern of regional food practices has been devised by W. Franklin Dove.[7-9] Dr. Dove's many other papers cover an integrated attack upon the whole problem of regional food patterns, nutritive value of foods, and the possibility of altering natural foods so that they make a more ideal contribution to a given food problem.

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[*] See "Social process and dietary change," by Herbert Passin and John W. Bennett on page 113 of this report.

[†] See "Outline of studies on food habits in the rural southeast," by Margaret T. Cussler and Mary L. de Give on page 109 of this report.

[‡] See "Forces behind food habits and methods of change," by Kurt Lewin on page 35 of this report.

From these various sources of data, combined with other partial sources of material on diet, resistance to change, rationalizations of resistance, etc., it is possible to identify various important social psychological characteristics of the American food pattern such as: the role of European peasant conceptions of status which have given an importance to white bread, much sugar, meat every day, etc.; the Puritan tradition of a connection between food which is healthful and food which is disliked, and the tendency in communities with a Puritan tradition to use food for purposes of reward and punishment and to handle delicious food as the reward for eating healthful, but disliked food; the equally definite Southeastern food pattern in which the emphasis is not upon health and duty but upon personal taste and a personal relationship between the eater and his food. Other tendencies which may be identified include the emphasis upon appearance of food rather than taste, an increasing preference for refined, purified, highly processed foods in which there is a minimum of waste material, and a parallel emphasis upon purity, packaging, etc. Culturally standardized objections to complex food dishes in which the constituents cannot be identified may also be referred, as may the characteristics listed above, to the situation in which people with very widely different food habits have found themselves in close association with each other, dependent upon alien cooking, alien serving, alien ownership and management of food distributing agencies. An investigation conducted by the Committee into ways in which emergency feeding could make maximum allowance for cultural differences in food habits [3] showed that the most practical way of avoiding giving offense to anyone in a mixed group is to cook single foods with a minimum of seasoning and serve all condiments separately. Contemporary cafeteria procedures in America and the large development of self-selected types of meals are an example of a social institution which is adapted to a variety of mutually incompatible food habits. It is probable that many other characteristic American attitudes toward foods, including taboos on all subjects which may arouse disgust during eating, may be referred to the experience of different mutually unacceptable food patterns. Up until the last year, with the exception of some types of company-owned towns, very few Americans under forty have ever had the experience of having money to buy food which, however, could not be obtained. The attitude of many European peasants who treat bread as sacred and guard against a single crumb falling on the floor has vanished in a country in which food was the certainty and money the uncertainty.

The patterning of food habits in other cultures is not only a significant source of materials from which useful abstractions may be drawn [10, 17, 22, 31] and a necessary background for understanding subcultural groups in the United States; [1, 13, 14, 28, 29] the food habits of other peoples are also significant for us because of the task of feeding liberated and war torn countries. Not only must the rations which we send be adapted to existing supplies of food, to carefully ascertained nutritional requirements and to the exigencies of transportation, but also, if they are to be of maximum use, the rations must be adapted to the food habits of the inhabitants of the various countries. The Committee has set up a series of cultural food experiments in which samples of a variety of concentrated emergency rations [*] are tested and worked over by groups of nationals of the various European countries to whom we may expect eventually to send food. On the basis of recommendations developed out of these test situations it will be possible to send with supplies of emergency rations detailed instructions in the native language as to the most acceptable method of cooking them.

As world food plans develop, the more data which we have upon ways in which existing supply can be adapted to traditional patterns so as to provide good nutrition, the more effective world-wide policies for improving nutrition will be.

In any study of food habits, it is important to define the patterns into which the available foods are arranged, such as number and form of meals, and the cultural—as opposed to the nutritional—equivalences which can be invoked within these patterns. So while a nutritional substitute for meat may be milk, the cultural substitute may be a "casserole" in which the container has been substituted for the thing contained, and food that is in no sense a substitute for a protein will be accepted when presented on the table in a suitably shaped container.[†]

Meal patterns are equally arbitrary and important, and alterations in the time or designation of a meal may mean severe nutritional dislocations, as when some Eastern Europeans, upon immigrating to America, dropped the second breakfast, or when odd-shift workers eat three meals, none of which is breakfast; [‡] and so the foods which customarily appear only at a breakfast table, fruit juice, cereal with milk, and eggs, tend to disappear from the diet. Shopping habits may have equally far reaching effect upon family food habits; for instance, since rationing, increased shopping by men and children of high school age has been reported. In the North American food pattern, the father presides over meat and fish, the mother over milk, vegetables, fruit juices and liver, while adolescents tend to demonstrate their independence by refusing to eat what is good for them. A shift in shopping habits resulting from the difficulties of using rationing coupons, increasing or irregular employment of women, etc., may therefore also affect the actual content of the meal, for, as Professor Lewin's study [§] has demonstrated, the person who controls the channel controls the diet of the family.

Recent studies of the effect of methods of food preparation on vitamin loss [12, 27] have pointed up the close relationship between habits of food preparation, such as the sharecropper's habit of leaving greens cooking on the stove while going to work in the fields,[30] or the forehanded housewife's habit of preparing vegetables before breakfast, and the nourishment which families will finally receive from the food prepared in this way. Similarly, the growth of institutional feeding, with increased dependence on the steam table, may have important nutritional implications so that a carefully cultivated habit of selecting a balanced meal which would be efficacious under one condition of food preparation may be wholly inadequate under other circumstances. Where meals have been set in a pattern of family life, either with the southern emphasis upon catering to the tastes of each member of the family [5b] or the northern emphasis upon moral overhauling of family members' behavior, conditions which isolate the individual and force him to eat alone may have important nutritional implications: the food associated with family living may be rejected entirely or overconsumed.

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[*] See "Tests of acceptability of emergency rations," by Natalie F. Joffe, on page 104 of this report.

[†] For the interpretation of data demonstrating the importance of size and shape of the meal item, I am indebted to Mr. John B. Lansing.

[‡] See "A study of the effect of odd-shifts upon the food habits of war workers," by Gladys Engel-Frisch on page 82 of this report.

[§] See "Forces behind food habits and methods of change," by Kurt Lewin on page 35 of this report.

Studies like those of Dr. Curt Richter [32, 33] on the ability of individual animals to select their own optimum diets also suggest that the nutrition of a people may be affected by habits of rigid food service in which each individual is served an exactly balanced meal without regard to individual preference. Such habits of food service as the individual plate and later types of blue plate service which are even invading the home all serve arbitrarily to standardize the food eaten by one person. Although it may be argued that such an arbitrarily balanced meal would be superior to the meals habitually eaten by the worst fed third of our population, there is a danger that the conventions of a balanced meal—plate service—may become established in the higher income levels and sift down as a style to the lower income levels, without the necessary knowledge to see that the meal is really balanced. The sort of individual adjustment which human beings, as well as rats, may conceivably make to an inadequate diet, such as reduction in caloric intake when the protective foods fell below a certain minimum, would then be ruled out by a food habit which had been nutritionally meaningful at a different income level. The whole tendency to train children in terms of "eating what's on your plate" introduces the same type of rigid category in the individual's relationship to his food.

When the culturally standardized dietary behavior has been described and analyzed, it is possible to consider the implications of experiments such as that of Festinger [11] on the preference manifested for the food less often eaten, or the relevancy of experiments in transfer of learning, etc., and to integrate them so that they will help in determining how to change American food habits and the results of such changes. Thus in every consideration, we do not think of an abstract human being eating an abstract food, but of particular human beings, members of an identifiable subculture of the United States, eating particular foods with definite qualities in addition to the socio-psychological values which have been assigned to that food by the culture. We do not ask, "How can we change food habits?" but rather, "How can we change the food habits of a community of second generation Americans of Polish, or Italian, or Hungarian extraction, where both men and women work in the mills and the average grade completed is the fifth?" or "How can we change the food habits of southern sharecroppers whose food habits are tied into a one crop method of production, type of credit allowed by the stores, rolling stores, habits of catering to individual preference and assigning ill health to the effects of particular foods, who live in a caste society where there is a characteristic rejection of any food identified as 'animal,' i.e., likely to lower the eater, etc.?" For such groups, definite methods can be discussed. Upon what ages of children, through what agencies, through what media should nutritionally valuable habits be urged? What sanctions should be used? How should new foods be presented or old, nutritionally undesirable foods be disparaged? Who should become the surrogate of the new nutrition knowledge, the mother, the teacher, the physician, the baseball hero, or moving picture actress, a puppet character like "Little Jackie" of the Dental Hygiene Division, South Carolina Public Health Service, the "government"? Should the emphasis be upon converting each individual to purposeful, careful eating or upon altering the style of American meals so that individuals will be well fed without having to exercise conscious and unremitting nutritional vigilance? [19, 20, 85]

Asking questions like these shifts the deliberations from such questions as, "Isn't the radio a good medium, shouldn't it be used more?" or "Wouldn't prestige and status be the easiest way to influence people?" to precise problems which can be stated in such a way that they can be answered. These precise questions become, "Under what conditions will individuals, with a known character structure, with known attitudes toward and ideas about food, eating a known diet, and with other known behaviors which will be affected by and will affect their food habits, tend to resist or accept an alteration in food preparation, food content, food proportions?" The task of applied science then is to set up a program for controlling a social process in such a way that the desired changes will occur, instead of a program aimed at the reform of identified individuals.

While it is possible to predict upon the basis of our available knowledge the general lines which acceptance of or resistance to change will follow, the Committee has found it necessary, in making specific recommendations, to make current studies of American attitudes on such matters as reduction in meat supply, relationship between food and morale, etc. The underlying attitudes which appear in these materials remain constant, and the studies are designed to reveal the situational impact of news, world events, and strictly contemporary conditions. A method of analysis of verbatim materials collected by the voluntary work of individuals and institutions throughout the country has been developed by Rhoda Métraux,* so that it is possible for the Committee to bring knowledge of basic cultural processes and American social psychological behavior to bear upon concrete problems. This method is not related to a Gallup poll. There is no intention of counting or getting an estimate of the number of individuals who would say they would be willing to drink more or less milk or eat soy bean products; the aim of the analysis is to show how existing situations are being interpreted by people of culturally standardized attitudes. So that by asking a question such as "How do you think people would feel if they were asked to eat more bread?" it is possible to work out whether more bread, as at present valued by Americans to whom it is not a principal food but to which an aura still attaches, will be regarded as a deprivation or an indulgence, a request to "eat something that is good for you," or a "reduction in the standard of living."

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* See "Qualitative attitude analysis. A technique for the study of verbal behavior," by Rhoda Métraux on page 86 of this report.

Recent developments in psychosomatic medicine have provided another approach to the problem. By studying the characteristic personality structure of individuals who manifest different marked gastrointestinal disorders or who come to clinics for treatment of obesity, food allergies and asthmas,[6] and anorexias,[34] it is possible to gain insight into the dynamics of the normal character development within our society and the role which food plays in that development. These extreme cases can serve as barometers of tendencies which appear, in less severe forms, in the general population. The delicate interrelationship between the way in which eating is culturally stylized and the expression of anxiety, fear, dependency, etc., can be shown from such detailed studies as Dr. Bruch's on obesity [*] and Drs. Wolff and Mittelman's [26] on the way in which such conditions shift over time.

In addition to the long-time contributions to our understanding of the part which learning to eat plays in character development, clinical studies can be utilized as indicators of the immediate reactions of selected parts of the population to threats of food shortage, or drastic alterations in diet. Both Dr. Bruch's [†] recent researches and a cooperative project now under way with the Emotions and Food Therapy Section of the American Dietetic Association,[21] in which food clinicians are making systematic observations of striking alterations in the behavior of clinic patients, are designed to tap this source of information. From psychiatric investigations we may also hope to get material on the more inarticulate bases of acceptances and rejections of food.[23]

While it is clear that any final adjustment of the food habits of a nation to the current findings of nutrition can best be established by a basic alteration in the culturally defined style of what is a meal and what is food, exigencies of wartime conditions have made it necessary to resort to special measures to accomplish immediate changes and adjustments to shortages and substitutes. Here the Committee was confronted with an already established program of directed social change. The officials of the change were trained home economists, some 15,000 members of a profession which developed about 35 years ago, in which many of the pioneers are still alive and, despite a membership from all over the country, in which the ethos and occupational style is quite homogeneous. In all directed efforts to alter existing food habits, the home economist is in a key position, whether to give food demonstrations, calculate new menus to fit shortages, set up new methods of food preservation, direct the professional propagandist of newspaper or radio, or train the neighborhood leader who is to carry word of mouth messages into homes not reached by other media. Preparation of materials in a form which could be used by home economists and experiments in procedures which would facilitate their tasks have therefore been an essential part of the Committee's work. A series of experiments by Professor Lewin,* have been designed to demonstrate methods of group decision in which the home economist could function most perfectly as an expert, with a minimum call upon her for the performance of miscellaneous activities not as directly dependent upon her special training.† The interdependence of the method of instruction at the top of a chain of communication and the reception which the information will receive at the bottom is also of importance in implementing the nutritional program.[4, 24]

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[*] See bibliography on page *72* of this report.

[†] See "Adjustment to dietary changes in various somatic disorders," by Hilde Bruch and Marjorie Janis on page 66 of this report.

Types of community organization most appropriate for the dissemination of information about food have also an important bearing on the wartime adjustment to food conditions and so the problem has been raised as to the relative efficiency of different forms. The study made by Mr. Koos at Cornell University Medical College in 1942 ‡ suggested that lines of friendship were not the best lines for the diffusion of nutrition information, and this finding was confirmed by the studies of Cussler and de Give.[5] This resistance may be systematically related to the phrasing of changes of food habits in moral terms and the objection to the exploitation of pleasant friendship relationships to pass on morally sanctioned information. The study of Passin, et al,[2] also showed that exchange of recipes for festive dishes was the only food content of personal relationships in the Southern Illinois community which they studied. While the block plan,§ [25] which invests a neighbor with a government sanction of patriotism and patriotic license for intrusion into domestic affairs, is probably more suitable than friendship lines, here also nutrition information can be discussed more efficiently if the emphasis is upon adjustment of meals to wartime conditions rather than upon eating correctly, upon helping a woman to adjust a process rather than urging her to be good. The neighborhood and block leader may show almost as much resistance to passing on information to her neighbors as she does to passing on information to her friends if that information is cast in terms which suggest that she is trying to reform her neighbor. If, on the other hand, nutrition information comes as news of ways in which food shortages or food shifts can be dealt with efficiently, such information will be passed on much more willingly and effectively.

During the entire war and immediate post-war period it will be necessary to implement two tasks: to devise ways in which the health of the people may be maintained by the most skillful use of the existing food supplies; to present an increased utilization of knowledge of nutrition in such a way that it does not become associated with the wartime period of deprivation, to be rejected later.[18] The long-time task is to alter Amercian food habits so that they are based upon tradition which embodies science and to do so in such a way that food habits at any period are sufficiently flexible to yield readily to new scientific findings. In order to accomplish this goal, the food habits of the future will have to be sanctioned not by authoritarian statements which breed rigid conformity rather than intelligent flexibility, but by a sense of responsibility on the part of those who plan meals for others to eat. At the same time it will be necessary to invent channels through which new findings can be readily translated into the meal planning of the woman on the farm, in the village, and in the city. To devise such a system of education, communication, and change which will link the daily habits of the people to the insight of the laboratory, and at the same time contribute to the development of a culture which produces individuals who are generally better adjusted as well as specifically better fed, is a task which requires a recognition of the total cultural equilibrium. Further, the application of science to improve eating habits may become empty and meaningless if it is not paralleled by efforts to apply science so as to increase the supply and adequate distribution of food. Efforts to better the nutrition of the world simply by altered production and distribution will also fall short of their goals unless corresponding and congruent changes are made in the patterns of consumption. The science of applied nutrition stands at the point [20] where a variety of techniques has been developed to deal with different aspects of the problem, and the most pressing problem is the integration of all of these techniques.

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* See "Forces behind food habits and methods of change," by Kurt Lewin on page 35 of this report.

† See "Summary of the Liaison Sessions on 'The wartime roles of the nutritionist' and 'Supplementing the role of the nutritionist at the household level,'" on page 158 of this report.

‡ See "A study of the use of the friendship pattern in nutrition education," by Earl L. Koos on page 74 of this report.

§ See "A summary of a study of some personality factors in block leaders in low income groups" on page 105 of this report.

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PART II

DEMONSTRATION AND RESEARCH CONDUCTED UNDER COMMITTEE AUSPICES

FORCES BEHIND FOOD HABITS AND METHODS OF CHANGE [*]

KURT LEWIN

INTRODUCTION

The following report is a partial account of a study conducted by a field staff [†‡] at the Child Welfare Research Station of the State University of Iowa. The objectives of the study were twofold; namely, 1) to investigate some aspects of *why* people eat what they eat, and, if possible, 2) to study methods of changing these food habits.

In studying the first question we have tried to combine approaches of cultural anthropology with quantitative methods of psychology. Two techniques were used. One is the Bavelas test,[1] a projective questionnaire,[5] with which 2,300 school children were tested.[§] The second method consists of interviewing housewives. Five groups were studied; three representing economic subdivision (high, medium, and low income levels) of White American stock, and two subcultural groups, Czech and Negro.

Several methods of changing food habits were compared experimentally. One experiment compares the effect of a method of group decision in one case with the effect of a lecture. Another experiment compares the effect of group decision with the effect of a request.

The results of the interviews with housewives are presented first.

I. WHY PEOPLE EAT WHAT THEY EAT

A. Method of Interviewing and Analysis

After a period of preliminary trials of various methods, the final data were collected during May and June, 1942. It should be kept in mind that the results describe the attitudes and habits of the people at that time (only sugar was rationed). The material was collected from the residents of a midwestern town with a population of about 60,000. Although surrounded by farming country, the town has a variety of industrial plants. It has employed a nutritionist for a number of years and has had a good nutrition program.

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[*] This study was financed by a grant from the Committee on Food Habits.

[†] The staff consisted of Alex Bavelas, Leon Festinger, Myrtle Hubbard, Patricia Woodward, and Alvin Zander. Alex Bavelas acted as "discussion leader," Myrtle Hubbard as "expert" or "lecturer" in some of the experiments. One experiment was conducted by Ben Willerman. Alvin Zander, Beatrice Wright and Patricia Woodward did a major share of the analyzing and writing.

[‡] Indebtedness is expressed to Dr. Sybil Woodruff, Head of the Department of Home Economics of the State University of Iowa, and to Prof. Lynn Garwood and Dr. Alice B. Salter, of the Department of Sociology, Coe College, Cedar Rapids, Iowa.

[§] A preliminary report[2] has been made but complete results are not yet available.

The interviewers, trained and carefully supervised by a member of the research staff, interviewed approximately an equal number of housewives in the three income groups and the two subcultural groups. The income of the low group did not exceed $1500 per year; that of the middle group did not exceed $2500 per year, and the high group was scattered, with the majority considerably above the upper limit of the middle group. The Czech women had been born in Europe and are comparable in economic level to the middle income group. None of the low income and Negro groups was on relief, but all were living on marginal incomes, although there is evidence that the Negro group is representative of a higher social level than the White group.

Each interviewer talked alternately with women from different groups so that no constant error due to the interviewer's personality or increasing routine would affect the results. A total of 107 housewives were interviewed, with approximately 20 in each of the five groups. Each interview lasted from 40 to 75 minutes.

The women in the high and middle income groups and in the Czech group were chosen as "typical" of that group by other residents of the city. The members of the low income group (White) and of the Negro group were selected by the director of the Community House serving the neighborhood in which most of them lived. In almost every case, the person who selected the interviewee explained to her that someone would be coming to see her. This considerably facilitated rapport.

One of the outstanding difficulties in analyzing data about foods is to find categories which have meaning from the nutritionist's point of view and still are in line with the everyday terms in which the housewife thinks and acts. The thinking of the housewife is guided by quite a variety of aspects such as health, money, food for husband, breakfast food, food for Thanksgiving, etc. It seems to be impossible to get a perfect classification system which takes in all these aspects at once. We have followed a line which, on the whole, tries to keep close to the thinking of the housewife.*

B. Channel Theory †

1. *General considerations.*

The question "why people eat what they eat," is rather complex, involving both cultural and psychological aspects (such as traditional foods and individual preferences caused by childhood experiences), as well as problems of transportation, availability of food in a particular area, and economic considerations. Therefore the first step in a scientific analysis is the treatment of the problem of where and how the psychological and the non-psychological aspects intersect. This question can be answered, at least in part, by a "channel theory."

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* The following are the 25 categories of food used for grouping the answers to the questions: bread (bread, rolls, buns, biscuits; does not include toast); butter; casserole (includes foods frequently prepared in a casserole, as spaghetti and macaroni); caffeins (coffee, tea, coca cola); cereal (dry and cooked); cheese; desserts (pies, puddings, custards, cakes, etc.); eggs; fish; flour; fowl; fruit; fruit juices; leftovers; meat (excluding fowl); milk (includes milk, buttermilk, cocoa, chocolate milk); potatoes; relishes (includes mustard, ketchup, other seasoning, pickles, spiced fruits, and vegetables); salads (fruit and vegetable salads); sandwiches; shortening; soup; sweets; toast; vegetables (including tomatoes but not potatoes).

† A diagrammatic representation of the *Channel Theory* appears in "Studies in topological and vector psychology III," edited by Kurt Lewin, to be published by the Child Welfare Research Station, State University of Iowa.

Of paramount importance in this theory is the fact that once food is on the table, most of it is eaten by someone in the family. Therefore one would find the main answer to the question "why people eat what they eat," if one could answer the question, "how food comes to the table and why."

Food comes to the table through various channels. One is buying in a store. After the food has been bought, it may be stored in a locker to be taken out later, then to be cooked and brought to the table. Another channel is gardening. There are additional channels such as deliveries, buying food in the country, baking at home, and canning.

a. *Food moves step by step* through a channel. The number of steps vary for different channels and for different foods within the same channel. The time food can remain in one position varies. Food in the locker or food after canning may remain for considerable time in the same position. Food may stay just a few hours or days in the pantry or in the icebox.

To find out what food comes to the table, we have to know how many food channels exist for the particular family or group. To understand the changes after certain channels are blocked, we have to know what new channels open up or in which old channels traffic is increased. For instance, when preparing meals at home becomes difficult, eating in restaurants may increase.

Food does not move by its own impetus. Entering or not entering a channel and moving from one section of a channel to another is effected by a "gatekeeper." For instance, in determining the food that enters the channel "buying" we should know whether the husband, the wife, or the maid does the buying. If it is the housewife, then the psychology of the housewife should be studied, especially her attitudes and behavior in the buying situation.

b. *The forces governing channels.* It is very important to realize that the psychological forces which influence the movement of the food may be different for the different channels and for the various sections within the same channel. Each channel offers a certain amount of resistance to movement, and certain forces tend to prevent entrance into the channel. For example, if food is expensive, two forces of opposite direction act on the housewife. She is in a conflict. The force away from spending too much money keeps the food from going into that channel. A second force corresponding to the attractiveness of the food tends to bring it into the channel.

Let us assume that the housewife decides to buy an expensive piece of meat: the food passes the gate. Now the housewife will be very eager not to waste it. The forces formerly opposing each other will now both point in the same direction: the high price that tended to keep the expensive food out is now the reason why the housewife makes sure that through all the difficulties the meat gets safely to the table and is eaten.

TABLE 1—PER CENT OF FOOD OBTAINED THROUGH VARIOUS CHANNELS*

Food	Buying					Gardening					Baking					Canning					Country				
	H N-23	M N-19	L N-21	C N-22	N N-21	H	M	L	C	N	H	M	L	C	N	H	M	L	C	N	H	M	L	C	N
Fish—Meat	91	100	96	99	96																			1	
Eggs	61	74	95	61	92																27	26	5	39	8
Milk	96	100	100	96	95																4			4	5
Butter	91	100	100	100	95																4				5
Fresh Vegetables	96	87	73	62	82	2	8	27	38	17												5			1
Canned Vegetables	86	83	65	45	68											14	15	34	55	31		1			
Bread	80	84	70	54	86						20	16	30	46	14										
Fresh Fruit	97	97	100	89	99				10	1												3			1
Canned Fruit	85	86	50	41	74											14	14	50	59	26					
Dessert	15	15	13	10	26						85	86	86	90	74										

* These percentages represent the average of the proportions of the food obtained through the particular channel as estimated by each individual.

H—High income group.
M—Middle income group.
L—White low income group.
C—Czechoslovakian group.
N—Negro group.

2. *The use of various channels.*

The question used in the interview to obtain information on the different channels used by the housewife was expressed in this form:

"People obtain food in many different ways. They may buy it in the store, or farm it, or can it. We are interested in finding out what these ways are. In what way does the bread you use come to your table?"

If several channels, such as buying and baking, were named, the interviewee was asked to estimate the proportion of the amount coming through each. Information was obtained for each of the following categories of food: 1) dairy products (eggs, milk, cheese), 2) fish and meat, 3) vegetables, 4) fruits, 5) desserts (cakes, pies), 6) bread (all forms). If different foods in the same category, such as eggs and milk, came through different channels, this was recorded also.

The results show that in the five groups studied, each of the foods, except desserts, is obtained through the buying channel considerably more frequently than through any other channel, as shown in Table 1.

However, there is a difference between groups in *shopping habits* (Table 2). On the whole there is a tendency to buy less than three times a week. The high income group is the only one which tends to buy more frequently than three times a week. The well-to-do housewife may not be as concerned with economizing on energy and time and is more likely to have a maid.

TABLE 2—Per Cent of Families Buying at Varying Intervals

Intervals	Total N-106	High N-23	Middle N-18 *	Low N-21	Czech N-23	Negro N-21
More frequently (at least 3 times per week)	25%	40%	17%	24%	18%	29%
Less frequently (less than 3 times per week)	40	27	33	34	57	48
Both—more frequently and less frequently	35	35	50	43	27	24

* Information on this question was not obtained from one person.

For all groups together, about a third of the vegetables and fruits are *canned* at home. There seems to be no relation between income levels and percentage of families who can. However, there is a cultural difference. All of the Czech families do some canning; the difference between them and every other group is significant with the exception of the low income group (Table 3). This, along with evidence to be presented later, suggests that the Czech group is more self-sufficient than any of the other groups. We find the *amount* of food canned to be greater in the two lowest income groups and the Czech

TABLE 3—Per Cent of Families Using Different Channels

	Total N-107	High N-23	Middle N-19	Low N-21	Czech N-23	Negro N-21
Home canning	83	74	79	90	100	71
Have gardens	52	17	47	57	87	52

TABLE 4—MEAN PER CENT OF FOOD CANNED AT HOME

	Two highest income groups	Two lowest income groups and Czechs
Vegetables	15	40
Fruits	14	45

than in the two highest income groups (Table 4). The most frequently canned vegetable for all the groups is tomatoes. The most frequently canned fruit is peaches. There are also differences in the *type* of food canned by the various groups: jams and jellies are canned by a significantly greater percentage of families from the middle and high income groups than from other groups. Noodles were canned only by Czechs; one woman showed the interviewer hundreds of quarts of noodles.

These results may be interpreted to mean that the motive for canning varies among the income groups. The lower income groups seem to be more guided by financial considerations and can essential foods whereas the high income groups can for taste and possibly status.

Table 3 shows that the two lowest income groups and the Czechs do significantly more *gardening* than the other two groups.

Lockers are used by almost 50% of the high income group, but by no families in any of the other groups.

The above discussion on food channels shows that to some extent financial circumstances and cultural values do influence the extent to which various food channels are used and the uses to which they are put. Thus, the lower income groups are able to effect savings by canning more of the essential foods they eat and by having more food gardens. The higher income groups are able to maintain lockers and have milk deliveries. The Czech group, resourceful and strongly motivated toward self-sufficiency, does the most canning and gardening.

3. *Who controls the channel.*

It is important to know what members of the family control the various channels, as any changes will have to be effected through those persons. In all our groups the wife definitely controls all the channels except that of gardening, and even there the husband seldom controls this channel alone. Children are never mentioned as controlling any of the channels, although they undoubtedly influence the decisions indirectly through their rejection of food put before them.

C. The Psychology of the Gatekeeper

To understand and influence food habits we have to know in addition to the objective food channels and objective availability, the psychological factors influencing the person who controls the channels.

The psychology of the gatekeeper includes a great variety of factors which we do not intend to cover fully. The factors might be classified under two headings, one pertaining to the cognitive structure, i.e., terms in which people think and speak about food; and the other pertaining to their motivation, e.g., the system of values behind their choice of food.

1. *The cognitive structure.*

The cognitive structure deals with what is considered "food," "food for us," or food for other members of the family, with meal patterns, and with the significance of the eating situation.

a. *Food outside and within consideration.* Physical availability is not the only factor which determines availability of food to the individual. One of the determining factors is "cultural availability." There are many edible materials which people never even consider for use because they do not think of them as food for themselves.

If we consider as food all that which some human beings actually eat and like to eat, then live grasshoppers would have to be included in the category of food. If, however, we ask what people in the United States consider as food, live grasshoppers would be excluded. In other words, the psychological area of food in our culture is only a small part of the objectively edible food, and could be represented diagrammatically as a small restricted region within the total region of all objectively edible food.

In some parts of our country peanuts or cheese are considered food for animals but not for human beings. A farm girl in Iowa refused to eat cottage cheese because it is something for the pigs. Even within the area of food in our culture, the boundary between food for human beings and food for animals varies.

Even the food that is recognized as that for human beings still may not be accepted as food for one's own family. For example, kidneys or certain viscera are considered by some as food only for poor people, or champagne a drink for the very rich. In other words, only a certain part of the area recognized as "food for human beings" is recognized as "food for us." To find out what is considered "food for us" by different groups is one of the first objectives of studying food habits.

b. *Food for husbands and children.* Within the area of "food for us" one might distinguish "food for the husband" and "food for children" as special subareas. The fact that the housewife controls the channels does not mean that she is not influenced by the preferences of the husband, or what she thinks is good for him and the children. Their indirect influence is shown in answer to the questions:

1. What things do you cook when your husband is home that you do not cook when he is away?
2. What things do you cook specially for your children that you would not cook otherwise?

The most typical husband's food (Table 5) is meat, which is mentioned by 39 per cent of the families, a significantly * greater per cent than those mentioning vegetables. Meat ranks first as a husband's food for all the subgroups except the Negro group where it ranks third, and vegetables and desserts precede it. On the other hand, the most typical children's food is vegetables, mentioned by one-third of the families having children. Vegetables rank first as a children's food for all the groups except the Negro group where it ranks second and desserts come first. Potatoes are served more frequently as a special dish for the husband than for the children.

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* The tests of significance used are in all cases either critical ratio between percentages, chi-square tests, or t tests. The critical ratio between percentages and the chi-square tests were used in instances where the numbers to be compared were simple frequencies, each individual appearing only once. In cases where one individual could appear many times, variability between individuals was calculated and a t test applied to the difference between mean number of times a given thing was mentioned.

TABLE 5—Rank Order of the Most Frequently Mentioned Foods Served for Husband and Children—Per Cent of Group

Husband

Total group N-107	High N-23	Middle N-19	Low N-21	Czech N-23	Negro N-21
Meats 39	Meats 43	Meats 48	Meats 48	Meats 39	Vegetables..38
Vegetables..21	Vegetables..32	Potatoes ...32	Potatoes ...33	Soups 26	Desserts ...33
Desserts ...21	Desserts ...13	Desserts ...26	Desserts ...29	Casserole ..13	Meats 19
Potatoes ...17	Cereals 9	Vegetables..26	Vegetables..19	Bakery 9	Potatoes ...14

Children

Total group N-88	High N-16	Middle N-19	Low N-21	Czech N-11	Negro N-21
Vegetables..32	Vegetables..31	Vegetables..26	Vegetables..24	Vegetables..45	Desserts ...29
Desserts ...23	Meats 31	Desserts ...21	Desserts ...24	Desserts ...17	Vegetables..24
Meats 16	Desserts ...19	Salads 21	Casserole ..19	Casserole ..17	Meats 19
Soups 11	Cereals 13	Meats 16	Soups 14		Soups 19
Potatoes ... 8					

This indirect control by other members of the family is one of the many aspects of the psychology of the gatekeeper.

c. *"Meal patterns."* Other aspects of the cognitive structure of food are the difference between breakfast food, food for lunch, and for dinner; the distinction between main dish and dessert; the concept of balanced meal and of "leftover."

The housewife was asked: "In what terms do you think of a meal: what goes into a breakfast? lunch? dinner?" As an answer she might say, "At dinner we have some kind of meat, a vegetable, salad, and a dessert," or "For lunch we either warm up leftovers, or try to have some other hot dish, as soup, with sandwiches and milk."

Because of the limitations of space, the lists of foods mentioned by each group will not be given, but some outstanding differences between the groups will be described. Cereal, caffeins (coffee, tea), eggs, and bread or toast are the most generally accepted *breakfast foods* by all the groups. Fruits are mentioned by three-fourths of the high and middle groups, but by only one-fourth of the Czech, Negro, and low groups.

As *lunch foods,* fruits and milk are mentioned more frequently by the high group, and soups more often by the low group. Salads, sandwiches, and fruits are much more characteristic of the high and middle income groups than of the others. Leftovers are used by more than half the Czech group, by about one-third of the high, low, and Negro groups, and one-sixth of the middle group.

Lunch is apparently a "pick-up" meal more than either of the other meals. Whereas approximately 75% of the high and middle groups claimed to plan their lunches, only 22 to 29% of the other three groups did. The others said they ate whatever happened to be in the house.

Meat, vegetables, potatoes, and dessert are commonly accepted by all groups as *foods for dinner*. Salads are mentioned much more frequently by the two highest income groups (69% as compared with 29%) while bread is listed less often, and butter not at all; 25% of the three lower groups name butter, and 33% name bread. It is likely that bread and butter are considered a real part of the dinner in these three groups, and only accessories by the two higher income groups.

One outstanding dimension of a culture is the *degree of homogeneity* of the individuals within it. A quantitative measure was developed which describes the degree of homogeneity in respect to food habits. Obviously, the more divergent the responses to a given question, the more heterogeneous the culture since more leeway for individual preference is permitted. When a culture is exceedingly strong in its dictates individual differences will be minimized. An index which ranges from 1/N to 1.00 (N being the number of people in the group) was thus devised to reflect these relationships.*

TABLE 6—HOMOGENEITY INDICES FOR BREAKFAST, LUNCH AND DINNER FOODS

	High N-23	Middle N-19	Low N-21	Czech N-23	Negro N-21
Breakfast	25	24	17	20	20
Lunch	24	10	7	9	6
Dinner	17	29	18	15	15

Table 6 shows the homogeneity indices (H.I.) for the three meals. The larger the H.I., the greater the similarity among the foods mentioned by the members of one group. This in turn can be interpreted as meaning that the culture defines the "meal pattern" more precisely than in those cases when the H.I.'s are smaller. There is considerably less agreement about the pattern for lunch than for either breakfast or dinner in all except the high group. This indicates that the families of the high group agree more than do the families of the other two groups as to what foods characterize lunch. In regard to dinner, there is considerably greater agreement among the members of the middle group than among the others.

The degree of homogeneity of meal patterns may be of particular importance in regard to changes in food habits. There are indications that, regardless of working hours, people eat according to the clock.[4] A worker waking at noon to go to work will eat a lunch meal rather than a breakfast, and nutritional elements which he ordinarily obtained through breakfast foods may be deficient in his diet. Moreover, since the results indicate that the lunches of all but the high group are the least "structured" of the three meals, it would follow that other foods might be fitted most easily into the lunch pattern.

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* The homogeneity index was calculated in the following way: the mean number of categories mentioned per individual was divided by the total number of different categories mentioned by the group. Thus, the highest homogeneity index possible would be one. This would occur if all the individuals mentioned the same categories. The lower the homogeneity index, the less agreement there is among the individuals making up the group.

d. *The meaning of the eating situation.* One important point is the feeling of group belongingness created by eating in the company of others. At a banquet, eating means something very different from eating after a long period of starvation, and may be classified as a social function rather than as a means of survival. On the whole, eating is usually a more complicated function than just taking nourishment.

The psychological meaning of eating is closely related to group situations. Eating with fellow-workers in a factory is something different from eating at the family table or eating in a restaurant. The "eating group" influences greatly the eating conduct and the eating ideology of the individual. One can say that every eating group has a specific eating culture.

2. *Motivation.*

We will discuss the various factors in motivation under three major headings; namely, a) values (motives, ideologies) behind food selection, b) food needs, and c) obstacles to be overcome.

a. *Values behind food selection.* There is more than one value which acts as a frame of reference for the individual choosing foods. These values have not always the same weight for the individual; they may change, as during wartime, and in addition may be different in the restaurant and at home.

The earlier, exploratory phase of the study indicated that at least four frames of reference are used in evaluating foods; namely, expense, health, taste, and status. It is important to know the relative strengths of these different frames of reference for various groups of people and also how they vary for different foods.

In regard to the system of values, three questions may be asked: 1) What are the values for this group? 2) What is the relative weight of each value? 3) How are specific foods linked with certain values?

1. *What are the values?* The usual informant is often unable to define the values which govern him because they are not thought of explicitly, but are part of a non-verbal implicit system of reference. Therefore we used two indirect methods for uncovering the value scales of the interviewee. The first consisted of watching carefully for all offhand comments to one of the following frames of reference:

a. Money, e.g., "Our family loves oranges, but we have stopped buying them. They are too expensive."
b. Health, e.g., "My children have to have a quart of milk a day for their teeth."
c. Taste, e.g., "I don't serve desserts at lunch time. We're not very fond of desserts."
d. Status, e.g., "We have our meats sent from Chicago."

Health considerations might be subdivided into the general idea of "good for you" or the more specific ideas of "good for teeth" or "vitamins." The values might be considered relative to the person himself or to other members of the family.

The interviewer noted such side remarks with a code letter in her running account of the interview, and wherever possible recorded the exact statement.

This method has recognized limitations in that an interviewee may take a value so for granted that she may not mention it or may be unable to mention it in the particular interviewing situation. For instance, the status factors are probably much stronger than they appear to be. However, the results obtained by this method show clear differences between the subgroups and present a coherent picture.

2. *Relative weight of different frames of reference.* There are significant differences in the frequency with which various frames of reference are mentioned both between the groups and within each group (Table 7).

TABLE 7—Average Frequency of Mention of Various Frames of Reference

Frame of reference	Total N-107	High N-23	Middle N-19	Low N-21	Czech N-23	Negro N-21
Money	2.80	1.30	3.57	3.81	2.21	3.42
Health	2.08	2.61	2.57	1.38	2.61	1.19
Taste	.90	1.34	.63	.76	.78	.95
Status	.04	.08	0	0	0	.14

Money and health came up significantly more often than other values for the group as a whole and for each subgroup except the high income group, whose taste plays an important role. *Money* is mentioned less frequently by the high group than by the middle, low, Negro (significant below the 5% level), and the Czech groups (significant at the 8% level). It is more frequently mentioned by the middle than by the Czech group (significant at the 2% level) despite the fact that they are at approximately the same income level.

Health is mentioned significantly more often by the high and the Czech groups than by the low and Negro groups; significantly more frequently by the middle group than by the Negro group; there is no significant difference between the middle and the low group.

Within the groups the following differences can be observed. In the high income group, health is the predominant value, with money and taste at a lower, approximately equal level. In the middle group money is the predominant frame, with health considerably lower, and taste a great deal lower. This is also true of the low income group except that the differential between money and health is even greater, money being by far the most important consideration. This picture is in general the same for the Negro group. The Czech group falls between the high and middle groups, in that their mention of money and health are approximately equal, with taste a great deal lower.

3. *Values and specific foods.* In order to know which food will be chosen one has to know, in addition to the general value system and the relative weight of each frame of reference, exactly where each of the foods in question

stands on each of the value scales. The following questions (asked at the end of the interview) were designed to bring out the relationship between value frames and certain foods:

a. What dishes would you be sure to serve if you were very short on *money?*
b. What dishes would you be sure to serve if your only consideration was *health?*
c. What dishes would you be sure to serve if your only consideration was *taste?*
d. What dishes would you be sure to serve if your only consideration was to put on a *"fuss"* and have a *company dinner?*
e. What foods would you be sure to serve if your only consideration was to *fill up* some people.

Table 8 shows the results for the total group in regard to their mention of meat dishes. Figure 1 gives the profiles for three specific meats.

TABLE 8—Per Cent of Total Group (N-107) Mentioning Various Meats in Answer to Five Frames of Reference

Meats	Short on money	Fill up	Health	Taste	Fuss
Fowl	4	6	2	14	40
Fish	4	0	5	7	1
Steaks and Chops	2	7	7	18	6
Roasts	6	11	5	8	23
Casseroles and Stews	6	5	2	2	2
Glandular and Chopped	18	12	11	5	2
Meat (general)	6	14	12	7	6
Meat (miscellaneous)	9	7	10	11	8

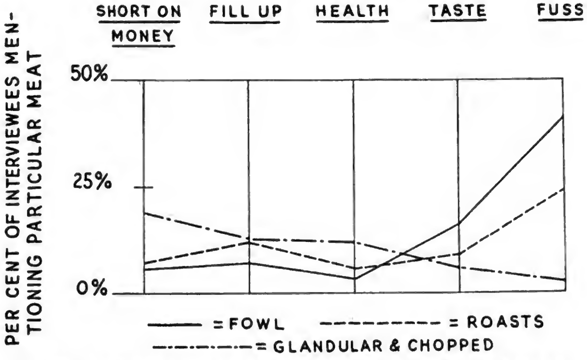

Figure 1.—Position of three kinds of meat along the five frames of reference for total group.

Fowl is almost never mentioned as a dish to have when short on money, or as a most healthful, or most filling food, but is mentioned by 40% of the group as a dish to have for a company dinner. This can be interpreted as meaning that in May and June, 1942 the housewife was not likely to buy fowl if she considered only money or health, but was likely to do so when buying for a company dinner. At the present time these considerations seem to have changed as a result of fowls not being rationed.

The position of the various foods on the taste scale was investigated, in addition, by asking the housewife, "What dishes are your family especially fond of?" This form was chosen because foods that are considered *favorite by the entire family* are more apt to reflect the effect of the general culture than the foods favored by an individual.

The average number of favorite dishes per family was approximately six in each group. As Table 9 shows, meats, desserts, and vegetables are the most frequent favorites in all groups except the Czechs who name bread significantly more often than desserts. That this category, bread, is so high for the Czechs is probably due to their large consumption of kolatches, a Czech dish made of dough similar to bread and stuffed with meat or fruit.

TABLE 9—RANK ORDER OF THE MOST FREQUENTLY MENTIONED FAMILY FAVORITE FOODS—PER CENT OF GROUP

High N-23	Middle N-19	Low N-21	Czech N-23	Negro N-21
Meats 87	Meats 79	Vegetables..76	Meats 87	Vegetables..95
Desserts ...48	Desserts ...79	Meats 57	Bread 78	Meats 67
Vegetables..35	Vegetables..63	Desserts ...57	Vegetables..61	Desserts ...67
Salads 30	Casserole ..53	Casserole ..24	Desserts ...35	Bread 48
Fish 22	Bread 42	.	Soups 30	Casserole ..43
Casserole ..21	Fruits 32		Casserole ..26	Fruits 24
			Fruits 22	

COMPARISON OF DIFFERENT INCOME LEVELS

	High	Middle	Low
Meats	87	79	57
Vegetables	35	63	76
Desserts	48	79	57
Casserole	21	53	57

Meat tends to be less mentioned as a favorite dish with decreasing income level. Vegetable dishes show the opposite trend and are mentioned significantly more often by the low and Negro group than by the high income group. This may be interpreted as supporting the hypothesis that people like what they eat rather than eat what they like. Our data do not give support to the widely prevalent idea that favorites are generally those foods which are difficult to obtain.

The housewife was asked, "What foods do you think are *essential* to a daily diet?" This question was introduced to obtain an over-all reaction of the housewife to the importance of foods within the diet. The degree to which a food is considered essential might be of particular importance in planning changes of food habits.

TABLE 10—RANK ORDER OF THE MOST FREQUENTLY MENTIONED ESSENTIAL FOODS—PER CENT OF GROUP

High N-23	Middle N-19	Low N-21	Czech N-23	Negro N-21
Vegetables..96	Vegetables.100	Vegetables..90	Vegetables..83	Vegetables..90
Milk 96	Milk 89	Milk 57	Milk 83	Milk 71
Meats 91	Fruits 89	Potatoes ...57	Meats 83	Meats 71
Fruits 74	Meats 84	Bread 48	Butter 52	Bread 52
Eggs 70	Eggs 63	Meats 43	Fruits 52	Fruits 48
Potatoes ...43	Potatoes ...53	Butter 33	Bread 52	Eggs 48
Butter 30	Bread 37	Eggs 29	Eggs 39	Potatoes ...48
Bread 22	Cereals 32	Fruits 29	Potatoes ...26	Butter 33
	Butter 21	Cereals 24		Cereals 19
	Fish 21			

COMPARISON OF DIFFERENT INCOME LEVELS

	High	Middle	Low
Vegetables	96	100	90
Milk	96	89	57
Meat	91	84	43
Fruit	74	89	29
Eggs	70	63	29
Bread	22	37	48
Potatoes	43	53	57

As shown in Table 10, vegetables and milk are the most frequently mentioned essential foods in all groups. Bread is considered essential by significantly more families from the low income group, the Czechs, and the Negroes, than from the high income group. Fruits are regarded as essential by four-fifths of the high and middle groups and by less than half of the three other groups; eggs by two-thirds of the high and middle groups and by about one-third of the others.

b. *Food needs.* It is important to recognize that the relative weight of the various frames of reference changes from day to day in line with the changing needs. These needs might change because of satiation, of variation in the situation, or because of cultural forces toward diet variations.

It is in line with the basic phenomena of all needs that continued consumption of the same type of food leads to a decrease in the attractiveness of that particular food. This is a powerful force toward daily and seasonal cycles in food choice. It affects different foods in different degrees; for instance, it is smaller for bread than for meat. Willerman's study[6] indicates, however, that even in the case of bread, which is something like a "background" food, the desire for variety can be noticeable.

The general level of food satisfaction, too, affects the attractiveness of food and changes the relative weight of the various value scales. If less food is within reach of a person the relative weight of the taste scale tends to diminish in favor of the "essential" aspects of food. If the food basket is pretty well filled the housewife can afford to be more discriminating in her choices than when it is empty.

The situational factors are fairly obvious: when the housewife is short on money at the end of the month or when she is preparing a meal for guests, the corresponding frames of reference will increase in weight.

The continued advocation of a "rich and varied diet" during the last decade has strengthened cultural forces toward day to day variations in foods.

c. *Obstacles to be overcome.* The interview did not approach the problem of obstacles along the various channels in a specific way, although these problems must be taken into account in planning changes of food habits. Canned foods, for instance, are frequently preferred because of the little time necessary for preparation. The extent to which such obstacles as difficulty in transportation, lack of domestic help, time necessary for preparing and cooking influence the choice of the gatekeeper depends on his particular circumstances.

3. *Conflict.*

a. *Buying as a decision situation.* We have discussed a number of forces which act toward or away from choosing a given food. Their simultaneous presence in the actual choice situation creates conflict.

In general a conflict situation arises when there is, on the one hand, a drive to engage in a certain activity (as buying food) and on the other hand, a force opposing that activity. An increase in prices, acting as a resistance to buying the foods which people have grown accustomed to, enhances the conflict in the food area for all groups. Families of low income are likely to experience more conflict in buying food than those of high income since their freedom in buying the foods they want is restricted by their limited finances. Members from the middle income group, however, may experience greater conflict than those from the low income group in so far as they are psychologically a marginal group. They strive to achieve the social status of the financially more able and at the same time fear dropping back to the level of poor people.

The degree to which a proposed change of food habits happens to touch a food area of high or low conflict is one of the factors determining the degree of emotionality with which people will react.

b. *Conflict in a situation of rising food prices.*

1. *Situation at time of study.* At the time of this study in the Iowa town, sugar rationing was just beginning; there were very few shortages in other commodities. However, prices of foodstuffs had gone up without a comparable rise in income and people were especially conscious of the rising cost of food.

Three questions concerning food retrenchment were asked: "1) Which foods are you *already cutting* because of the increase in the price of food? 2) If prices continue to rise, which foods *might* you cut? 3) Even if prices continue to rise, which foods are you particularly anxious *not* to cut?"

As might be expected (Table 11) the high income group *has cut* fewer foods than any other group. The next in line are the Czechs. Both groups have cut significantly less than the middle, low, and Negro groups. The middle group has cut almost the same number as the low group, both rather heavily, namely, almost 2½ foods per person.

TABLE 11—AVERAGE NUMBER OF FOODS NAMED IN ANSWER TO CONFLICT QUESTIONS

	Total N-104	High N-23	Middle N-18	Low N-21	Czech N-23	Negro N-19
Already Cut	1.73	.96	2.33	2.38	1.17	2.05
May Cut	.79	.57	1.11	.38	1.52	.32
Don't Want to Cut	.40	2.39	2.94	2.24	1.87	2.74

In regard to foods they *might cut* the Czechs list more than any other group. At the same time they list fewer foods which they do not want to cut than any other group. Their willingness to get along on fewer foods may be partially due to their past experience. Their attitudes were expressed succinctly in the comments of several of the housewives: "In the old country we were used to getting along on much less. It takes more time to fix it, but we can do it." "I'd make everything go farther. I always had to do that in the old country—stretch things as far as they could go and do without meat except once a week." "In the last war we cut down on sugar, mixed butter with oleo, and stretched meat by using gravies and soups, and we could do it again."

The low income groups can be assumed to be using a smaller variety of foods and consequently would realistically mention fewer foods which they might cut. The high group, on the other hand, in spite of their greater variety of foods, does not expect to cut much, probably because of their wider margin of financial security.

2. *General intensity of conflict.* The following scale of conflict ratings was used in determining the total conflict rating for each individual. The term "food" refers to one of the 25 food categories used in classifying foods throughout this study.*

1. Given to foods mentioned in answer to *only one* of the three questions.
2. Given to foods mentioned in answer to *both* questions 1 and 2.
3. Given to foods mentioned in answer to *both* questions 2 and 3.
4. Given to foods mentioned in answer to *both* questions 1 and 3.

The reasoning behind this arbitrarily established rating "scale" was that there is some conflict associated with a given food if it is mentioned in answer to any one of the questions, but that the conflict shows a progressive increase 1) if the food has already been cut and may be cut still further, 2) if the food might be cut but is one which the individual does not want to cut, and still more 3) if the food is one which has already been cut but is one which the individual does not want to cut. There may be some differences in the conflict expressed by an answer to *any one* of the three questions (rating of 1), but such a distinction would involve a finer scale than was thought necessary for the purpose of this analysis.

The maximum conflict rating that could be obtained by any one individual would be 100, that is, all 25 foods with a conflict rating of 4. Such a score is practically unattainable, however, since no individual has cut every type of food. The scores of the group studied ranged from 0 to 13 and are shown in Table 12.

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* See footnote on page 36.

TABLE 12—AVERAGE CONFLICT RATINGS FOR THE FIVE GROUPS

	High N-23	Middle N-18 *	Low N-21	Czech N-23	Negro N-19 †
Average Conflict Rating........	4.35	7.44	5.62	5.15	5.74

* One person did not answer these questions.
† Two persons did not answer these questions.

The average conflict rating (Table 12) for the middle group is significantly higher than that for the high group and for the Czech group. The high income group, being the most secure financially, would be expected to feel the effects of the rise in prices the least and to have made the least changes because of them. The middle group feels the rise in prices most for several reasons: 1) they are in a marginal position; the future holds more of a threat for the middle class; in the effort to resist lowering their social status they might economize first in those areas which are socially least prominent, such as food, thus keeping up appearances; 2) they are accustomed to depending less upon home canning and other economizing measures than are the lower income groups; 3) their dominant frame of reference is money (see Table 7) which is mentioned spontaneously by them almost as frequently as by the lower income groups. At the same time they emphasize health almost as much as the high group and much more than the lower group. Therefore, a rise in prices can more easily bring about a rise of conflict for this group than for the others.

3. *Conflict in regard to special foods.* The relationship of the conflict rating to specific food categories is shown in Table 13.

TABLE 13—CONFLICT RATING OF FOODS FOR DIFFERENT GROUPS

Total group		High		Middle		Low		Czech		Negro	
Food	Conflict rating	Food	Conflict rating	Food	Conflict rating	Food	Conflict rating	Food	Conflict rating	Food	Conflict rating
Meats ...	1.09	Vegetables	.87	Vegetables	1.44	Meats ...	.95	Meats ...	1.57	Meats ...	1.00
Vegetables	.75	Milk	.70	Meats ...	1.28	Potatoes ..	.76	Vegetables	.48	Milk	.84
Milk	.62	Meats ...	.65	Butter ...	.94	Butter ...	.67	Milk	.43	Eggs	.68
Butter ...	.56	Fruits ...	.43	Fruits ...	.94	Fruits ...	.62	Sweets ...	.43	Butter ...	.63
Fruits ...	.54	Eggs	.39	Milk	.89	Vegetables	.57	Fruits ...	.39	Sweets ...	.53
Eggs	.37	Butter ...	.30	Dessert † ..	.39	Eggs	.33	Butter ...	.35	Vegetables	.47
Sweets * ..	.32			Potatoes ..	.33	Milk	.33	Bread ...	.35	Desserts ..	.32
Potatoes ..	.30					Bread ‡ ...	.33				

COMPARISON OF DIFFERENT INCOME LEVELS

	High	Middle	Low
Milk	.70	.89	.33
Meat	.65	1.28	.95
Butter	.30	.94	.67
Fruits	.43	.94	.62
Potatoes	..	.33	.76

* Sweets refer mostly to sugar but also include candy and ice cream.
† Desserts include pies, cakes, puddings.
‡ Bread includes bread, rolls, buns, but not toast.

For the total group, *meat* has a significantly higher conflict rating than that of any other food. Its conflict rating, however, varies considerably among the groups, being lowest for the high group and highest for the Czechs and middle group. Although the Czechs are relatively willing to cut meat consumption, they show strong conflict in this area. The position of meat in the rank orders of conflict foods increases from third place in the high group to first place in the low group.

Vegetables and *milk* are second and third highest in the total group.

The change in the position of *potatoes* from seventh in the middle group to second in the low group can be considered an indication of their position in the diet of these two groups. The great importance of potatoes to the low income group is substantiated by such comments as: "Have to have potatoes at least once a day," or "If I cooked three meals a day without potatoes (at each meal), there would be quite a fuss."

Table 14 gives the conflict ratings for the total group and the frequency of the various food categories in answer to each of the three questions regarding food retrenchment.

TABLE 14—ANSWERS OF TOTAL GROUP TO QUESTIONS REGARDING ESSENTIAL FOODS, FOOD RETRENCHMENT, WITH CONFLICT RATINGS

Food	Conflict rating	Per cent judging it essential	Per cent of families who have already cut	Per cent of families who may cut	Per cent of families who do not want to cut
Meat	1.09	75	47	22	24
Vegetables	.75	92	12	6	40
Milk	.62	80	4	1	50
Butter	.56	34	17	6	29
Fruit	.54	57	12	7	26
Eggs	.37	50	8	2	26
Potatoes	.30	45	9	5	13
Bread	.21	42	7	5	6
Sweets	.32	6	17	7	4
Desserts	.19	3	12	6	1

The three foods which produce the greatest conflict, namely, meat, vegetables, and milk, are also those which are considered most essential. Meat has been by far the most frequently cut food. Although it is considered an essential food, it is one of the most expensive, and cutting it could produce a greater saving than cutting any other food.

Only those foods which are considered to be essential are among those which the people say they do not wish to cut. Those which are not considered essential, such as desserts and sweets, are mentioned by very few in answer to this question.

D. Roles Played by Various Foods

The description of the roles played by each food is based on an analysis of the answers to all the questions.* Space permits mentioning here but a few of the foods:

Meat—fulfills many roles in the American culture. It is almost always considered as a food for dinner, no matter whether the function of the meal is to be filling, tasty, fussy, healthful, or economical. It is a favorite and essential food for all groups. It is regarded as a special food for the husband by all groups except the Negro group. Meat is the food most frequently mentioned by all the groups as cut due to price increase.

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* It should be emphasized that these descriptions cannot be considered as complete. Nevertheless these descriptions are an indicator of the kinds of information that can be obtained.

Meat is not thought of as a food for lunch when eaten at home.

Milk—ranks second to vegetables as an essential food for the groups as a whole. None of the income groups wishes to cut it even though prices are rising. It is considered a breakfast and luncheon food by about one-third of the people.

Milk is not a food that people are cutting. It is not thought of when considering "fuss" occasions and is rarely mentioned as a taste favorite or a filling food. Milk is not a special food for the husband.

Potatoes—are accepted by all groups as a food for dinner. They are an essential food and are also thought of as a filling food. The three lower income levels (low, Negro,.and Czech) tend to regard potatoes as part of a "fuss" meal more frequently than do the two higher income levels.

Potatoes are rarely thought of as a food for breakfast or as a luncheon food. They are never mentioned as a favorite.

Salads—are thought of most frequently as a food for dinner. They are next most frequently seen as appealing to the taste and as appropriate to a "fuss" dinner. The high and middle income levels consider them as a food for lunch, but the three low income levels seldom mention them as a luncheon food. In general, salads play a more prominent role in the diet of the two highest income levels than of the others.

Salads are not considered an essential food, though they are mentioned by about one-fourth of the people as a healthful food. They seldom appear as a special husband's or children's food and are never mentioned as a breakfast food.

E. Application to Problems of Change

How strong the forces are which resist changes of food habits in a certain direction can be investigated finally only by actual attempts to change food habits, that is, by an experimental approach. No amount of questionnairing can be a substitute for experiments. However, much of the data gathered from the interviews can be helpful in planning experiments.

We will discuss first the results of the specific question concerning substitute foods and then summarize the findings related to the problem of change.

1. *Substitutability of essential foods.*

The effect of certain motivational forces toward changes in food habits will depend upon the flexibility of these habits. One factor related to flexibility is the degree to which food which becomes undesirable or unattainable can be replaced by another food.

We approached this question by asking the housewives what they would substitute for each of the foods listed as essential. No instructions were given them as to the number of substitutes they should mention, but they were asked what they would substitute for each of the essential foods they named. In general the substitutes fall into nutritionally similar categories: oranges for lemons, fats for shortening, cheese and eggs for meat, oleomargarine for butter, another kind of vegetable for the one named, fruits for vegetables, etc. Nutritionally dissimilar substitutes were mentioned only by those in the low income group. Examples of these are shown in Table 15.

TABLE 15—ESSENTIAL FOODS WITH NUTRITIONALLY DISSIMILAR SUBSTITUTES

Essential food	No. times mentioned	Substitute	No. times mentioned
Eggs	6	A specific kind of cereal	3
Milk	12	Fruit juices	4
Vegetables	19	Gravy	3

Table 15 indicates that the degree of difference between foods which can still be substituted for each other is greater for the low than for the high income group. This is in line with the fact that the lower the level of satisfaction of a need the greater is the range of possible consummatory actions for it.

2. *Basis of change of food habits.*

Changes in *availability* of food is one obvious cause of changes of food habits. The area of available food may shrink considerably, as is the case in a situation of shortages. This necessitates a change in type and frequently in amount of consumption.

A second cause of changes of eating habits is a change concerning the food *channels*. An example of shifting to more available channels at the present time is the change to gardening and canning.

A third possibility is a psychological change: a food that had been considered *"food for others, but not for us"* may become *"food for us."* Food shortages may facilitate such change. An example is the increased use of glandular meats since the beginning of rationing. Whereas a housewife might heretofore have passed them by, she may now consider them seriously and buy them frequently because of their availability and low "point cost." Similar changes can occur with respect to patterns of meals. In the American culture the "food basket" has three distinct parts assigned to breakfast, lunch, dinner: many foods are considered fit for only one part. In case of food shortage this might change. Since lunch is the least structured meal (see Table 6) there might be a greater readiness to change the content of the "lunch" than of the other meals.

A fourth possibility for change in food habits is to *change the potencies of the frames of reference.* This can be accomplished in one of two ways: 1) Changing the *relative potency* of the frames of reference. For example, the current emphasis upon nutritional eating has been planned to increase the relative potency of the "health" frame of reference. ("Eating well to make a strong nation.") 2) Changing the *content* of the frames of reference, that is, the foods related to them. At the present time (May, 1943) the position of fowl has undoubtedly changed from that of a "fuss" food, in the direction of an everyday substitute for other meats which are less available. It is quite possible that there was some resistance at first to using it as an "ordinary" meat for everyday meals because of its high position in the "fuss" or "company" frame of reference.

A fifth possibility for change is a *change in belongingness to "eating groups."* Increased incidence of school luncheons and eating in factories should be mentioned here.

II. EXPERIMENTS IN CHANGING FOOD HABITS

Limitations of time permitted only a few preliminary experiments with changes in food habits. Obviously a great variety of methods can and have been used to bring about change in food habits. They vary all the way from an elaborate treatment of the individual (for instance, in cases of problem children) to mass propaganda by radio, newspaper, billboard, etc. We have chosen for our study techniques which lie halfway between the individual and the mass approach. They are intended for face-to-face groups with an optimum size of 15 to 50 persons. The approach is not so impersonal as advertisement but lends itself well to relatively quick application to fairly large numbers.

Various degrees and types of pressure can be used in the attempt to influence other people. Straight orders with the threat of severe punishment may stand on one end of this continuum—free choices on the other. In addition, changes may be brought about by a frank, open approach or by "manipulating" people, putting up what actually is a false front and tricking them into certain behavior.

"Democratic" methods in regard to changes of groups have been frequently attacked as being rather wasteful. We have been particularly interested in trying out a method which we have named "group decision." A group decision has one aspect in common with group discussion; namely, that a free interchange of ideas takes place and that in many respects the initiative lies with the group. No attempt is made to force a decision on the group or to use high-pressure salesmanship. On the other hand, unlike a mere group discussion, group decision leads to a setting up of definite goals for action. These goals may be set up by the group as a whole for the group as a whole[6] or by each individual in the group setting for himself.[3] Unfortunately there is no space here to give the necessary details of the method. It may be stated that it is by no means simple to lead a group discussion within forty-five minutes to a conclusion without "manipulation." The procedure obviously requires very thorough considerations in regard to the creation of a proper atmosphere, a definite leadership, and the use of experts in the right way at the appropriate time. It is planned to give a full account of these experiments elsewhere.

*A. Group Decision and Request as Means of Changing Food Habits** [6]

This first experiment attempted to determine the relative effectiveness of two methods for changing food habits of a group: 1) *Group decision*—the group decides for itself whether and to what degree it wishes to change its habits. 2) *Request*—the group is requested to make a change to a certain extent.

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* This experiment was conducted by Ben Willerman.

1. *Subjects and procedures.*

The experiment was concerned with the increase in consumption of whole wheat bread as compared with white bread. It was conducted during April and May, 1942. Eight cooperative dormitories for men students at the State University of Iowa were used. Their membership ranged from 20 to 44 men; the average age of the students was approximately 21 years.

The eight co-ops were grouped into four pairs, each pair being matched on the basis of similar percentage consumption of whole wheat bread at the start. One of each pair was to make a *group decision* and the other was presented with a *request*.

For a week preceding the experiment and during the experimental period of one week, only whole wheat and white bread were served. During these two periods daily measures of consumption of both kinds of bread were made by student waiters. They were instructed to keep the dining-room tables supplied with both kinds of bread throughout the meals so that the members could choose freely.

The student proctor of each of the dormitories understood beforehand that he would receive a letter by an authority to be read at the end of the meal when all members were present. After reading the letter which instigates "group decision," he would ask for discussion of the proposal. If the group agreed to cooperate in the experiment, he would ask them to decide how much they would increase their whole wheat consumption for the following week. The "request proctor" was merely to read the request letter and ask for comments. All groups were informed of their previous average percentage consumption of whole wheat.

The amount of change desired of a particular request group was set at the same level as the amount which had been voluntarily chosen by that decision group with which it was paired. A description of the meetings was obtained by an observer. After the experimental period the members were asked to fill out a questionnaire about their bread preferences, and about various aspects of the experiments.

2. *Results.*

a. *The level of the group goals.* All group decision co-ops voted for an increase of whole wheat consumption. From their previous levels of approximately 50%, one group decided to go to the 66% level, one to 90% and two to 100%.

Of the two groups which voted for 100%, group C was very enthusiastic over the proposal and quickly and unanimously voted for that goal. Group D was fairly evenly divided between setting a 100% goal and setting a lower goal. The 100% level was decided upon by a small majority only after a rather bitter fight. The results of the questionnaire indicate in a striking way the effect of this disagreement.

The two request groups who were asked to raise their whole wheat consumption to 100% did not resist this imposition of an extreme goal.

b. *The effect of group decision and request.*

1. *Change in consumption.* The effect of the group decision as compared with the request can be measured by the difference in the amount of actual change in consumption and by the attitudes of the group members as revealed by the questionnaire.

Various circumstances interfered with the getting of satisfactory records of consumption in this experiment; for example, the group that had voluntarily chosen to increase whole wheat consumption to 90% advised the waiter to serve but a few slices of white bread. This was an expression of their eagerness to reach the group goal but prevented a scientific comparison. Other groups did not have sufficient bread of one or the other type delivered by the bakers.

From the data available we observe a superiority of the group decision co-ops. The group decision co-ops that set their goals at 66% and 90% reached their goals, whereas the parallel request co-ops did not.

2. *The immediate reaction to the proposal.* The questionnaire which was filled out after the experiment by those students of the co-ops who had not left for vacation contained two questions related to their immediate reactions to the proposal.

Question a): "When the proctor read the letter announcing the experiment, what was your reaction to it?"

Of the request groups (Table 16), about half were favorable (48%); the rest mainly indifferent. Of the group decision groups (excluding Group D), the great majority of the members (78%) were favorably inclined. Only 11% were indifferent and only 3% unfavorable. Group D, however, which decided by a very small majority on 100% whole wheat consumption, had more than half of the members reacting unfavorably.

TABLE 16—REACTION TO PROPOSAL TO PARTICIPATE IN THE EXPERIMENT

		Favorable	Indifferent	Unfavorable	Miscellaneous
Request Co-ops (E, F, G, H)	N	19	16	2	3
	%	48%	40%	5%	8%
Group Decision Co-ops					
(A, B, C)	N	28	4	1	3
	%	78%	11%	3%	8%
(D)	N	5	4	12	0
	%	24%	19%	57%	0%

N = number of persons participating in the experiment.

On the whole, we can say that a group decision to change food habits is more favorably accepted than a request from someone outside the group. However, a decision with a very small majority led to a reaction which was decisively less favorable than the reaction to the request.

Question b): "Did you feel that the goal set for the group was just right, too high, or too low?" elicited similar reactions from both the members of the request and group decision co-ops. The great majority (80% of request groups and 86% of group decision groups) felt that the level set was right. This seemed to be independent of whether the goal was set relatively close to or far above the previous consumption.

Group D which had made its decision by a small majority shows also in this question its discontent: most of the members (78%) considered the goal too high, but the remainder (22%) said it was "just right."

3. *Eagerness to reach the goal level.* One question was asked referring to the person's own eagerness to succeed, another referring to his judgment about the eagerness of the group as a whole.

Question a): "How eager were you for the group to reach its goal?" This was answered on a scale ranging from a plus-4 to a minus-4. The middle point, 0, meant: didn't care one way or the other.

The members of three of the group decision co-ops rated themselves more eager to succeed than did the members of the parallel request co-ops (Table 17). The only exception was again Group D. The members of this group rated their own eagerness lower than any other group.

TABLE 17—Eagerness to Succeed

	Rating of own eagerness		Rating of group's eagerness	
Goal level	Gr. dec.	Request	Gr. dec.	Request
66%	2.5	1.9	2.4	1.8
90%	2.8	2.0	2.6	1.6
100%	3.6	2.6	2.8	1.8
Average	2.9	2.1	2.6	1.7
100%	1.0 (Co-op D)	2.0	— 0.4 (Co-op D)	2.0

Question b): "How eager do you think the group as a whole was to reach their goal?" With the exception of Group D the members of the group decision co-ops judged their own group to be more eager to succeed than did the members of the request groups. Group D again showed by far the least eagerness to succeed. In fact, they expressed on the average the opinion that their group had a slight wish not to succeed (Table 17).

On the whole, then, we can say, if we disregard Group D, that all co-ops were *satisfied with the level set* for the change of their food habits independently of whether this goal was introduced by group decision or request and independently of whether it was high or low. The members of the *group decision* co-ops showed more favorable attitudes to the proposition as a whole and were more eager to succeed. In one co-op where group decision was based on but a slight majority, the attitude was decidedly unfavorable. There was little or no eagerness to succeed and the goal level was considered too high.

As a point of general interest it might be mentioned that the individuals rated their own eagerness to succeed higher than that of the eagerness of the other members of the group. This holds true for both the group decision co-ops and the request co-ops with the exception of one request co-op where the rating was equal (Table 17).

4. *Food preferences and eagerness to succeed.* For members of the request co-ops there is a definite relation between their eagerness to succeed and their personal preference for whole wheat as against white bread (Table 18). The more they preferred whole wheat, the more eager they were for the group to succeed. The members of the group decision co-ops did not show this relationship. *Independent of their personal likes and dislikes,* they were equally eager to see the group succeed.

TABLE 18—RELATION BETWEEN ORIGINAL PREFERENCE FOR WHOLE WHEAT BREAD AND EAGERNESS TO REACH GOAL

	Prefers whole wheat		No preference	Prefers white bread	
	Very much	Much		Much	Very much
Request Co-ops	2.4(14)	2.3(14)	1.9(7)	1.3 (6)	0 (1)
Group Decision Co-ops (A, B, C)	3.2 (5)	3.2(11)	3.3(7)	3.3(10)	1.7(3)
Group Decision Co-op D	(0)	3.7 (3)	1.1(7)	1.5 (4)	−2.0(6)

The numbers refer to average ratings of preference.
The numbers in parentheses refer to the number of individuals.

This indicates that in *case of an external request* the wish to succeed or not to succeed depends largely upon whether or not the personal likes happen to be in line with the request. *A group decision,* on the other hand, seems to establish a sufficiently strong group goal to be accepted by the members in a way which overrules to a considerable degree personal taste.

The motivation induced by group decision is higher than that of the request groups in spite of the fact that, in our sample, the preference for whole wheat is greater in the latter (average of 3.7 as compared with 2.9 on a 4-point scale).

That the psychological acceptance of the group rather than the form of group decision is the decisive factor is illustrated by Group D which had a small majority decision. Those members of that group who preferred white bread very much had a strongly negative attitude toward reaching the goal.

c. *The effect of increased consumption on preference.* The increased consumption of whole wheat bread during one week seemed to have led to a slight increase in preference for this food. Those members whose ratings could not increase (already had a rating of "prefer whole wheat very much") or decrease (had rating of "prefer white bread very much") were omitted from the tabulation. Of the others in the group decision co-ops, 23% increased their preference for whole wheat, while 0% decreased. In the request co-ops, 26% increased their preference, and 2% decreased. Group D, with the small majority decision, shows the opposite trend, with 5% increase and 20% decrease.

d. *Effect of goal levels on attitudes toward future consumption.* There seemed to be a difference in the attitude toward future consumption of whole wheat bread between those groups whose experimental goal was below 100% and those on the 100% level. Eighty-three per cent of the former groups wished to remain at or increase their level whereas only 18% of the latter groups wanted to maintain their 100% level. A bread diet of only whole wheat seems to lead to psychological satiation and a desire for variety.

3. *Summary.*

A method of group decision is compared with a method of request in its effect on changes in food habits and related attitudes. The group decision method seems to create a more favorable attitude; the individuals are more eager to succeed; and their wish to cooperate is more independent of their personal likes and dislikes.

If the group decision is based upon too small a majority there is danger of a "kick-back" which seems to make the outcome even less favorable than that of the request method.

B. The Relative Effectiveness of a Lecture Method and a Method of Group Decision for Changing Food Habits[*][5]

1. *The problem.*

The interest in the group decision method stemmed from the realization that even strong motivation may not suffice to change the action of a person in regard to his food habits. Motivation leads to action only if it is brought down from the level of wishes and sentiments to the level of a "decision."

This experiment was an attempt to evaluate the effectiveness of a group decision procedure, in which a nutrition expert cooperates with a group-discussion leader. The expert provides the technical knowledge in a social setting which induces decision.

The change in food habits instigated by the nutritionist in a group decision setting was compared with the effect of the same nutritionist in a lecture setting.

2. *Experimental procedure.*

a. *Length of meeting.* Since practical usefulness of any procedure for changing food habits on a large scale demands that the method not be too elaborate or time consuming, both the lecture and the group decision procedures were limited to about thirty minutes.

b. *Food changes attempted.* It was thought that attempting a rather difficult food habit change would be a more severe test of the method, thus permitting safer conclusions. A preliminary experiment which attempted to introduce a new vegetable (escarole) showed the feasibility of the group-discussion method. In the present experiment kidneys, brains, and hearts were chosen because of the known resistance to these foods. There are definite indications that this resistance is a rather deep one, frequently combining elements of physical aversion, social status, and superstition.

c. *The groups used.* To permit comparison of the method of change, two groups of women were selected from each economic level, one for the lecture method and one for the group decision method. One pair of groups came from the best residential areas, one from substantial middle class homes, and one from a lower economic stratum but still above subsistence level.

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[*] Indebtedness is expressed to the Cedar Rapids Red Cross, the Cedar Rapids Nutrition Service and the Home Economics Department of the State University of Iowa for their cooperation and assistance in the conduct of the study.

All six groups, ranging in size from 13 to 17 members, had already been organized for Red Cross Home Nursing courses and met regularly at private homes or schools for the Red Cross course.

d. *Experts and group leaders used.* Mrs. Mulqueen, who has been the city nutritionist in Cedar Rapids, Iowa, for several years, and Mrs. Hubbard, who is recognized as a leading American volunteer leader and organizer in the field of nutrition, both functioned in some of the lectures and group decisions. They were selected so that a comparison could be made between the group decision procedure and superior nutrition lectures.

The leader of group decision was Mr. Bavelas, who has had considerable experience in group work.

3. *Procedures used in the lecture and group decision.*

Stenographic records were made of some of the lectures and of the group decisions. Briefly, the procedure in each case was as follows:

a. *Lecture.* The lecturer linked the problem of nutrition with the war effort, emphasized the vitamin and mineral value of the three meats giving detailed explanations with the aid of charts. Both the health and economic aspects were stressed.

The preparation of these meats was discussed in detail as well as techniques for avoiding those characteristics of these meats to which aversions were oriented (odor, texture, appearance, etc.). Mimeographed recipes were distributed. The lecturer was able to arouse the interest of the groups by giving hints of her own method for preparing these "delicious dishes," and her success with her own family.

b. *Group decision.* The group decision method is based on a cooperation between the group leader and the expert. It should be emphasized that no attempt is made to "high-pressure" the group into any kind of "promise" to serve these foods.

The group-discussion leader starts with a very short introduction linking the problem of nutrition with the war effort and with general health. He points to the difficulties the government has met in trying to change food habits, and asks the opinion of the women, as a representative group of housewives, as to how successful a direct appeal to groups of housewives like themselves would be. From here on, the group is led step-by-step to seeing the problem more concretely, and, at the same time, to taking over the responsibility "to do something about it." This point is reached through a free group discussion which also brings out the specific reasons why the meats have been rejected by the housewife herself or by her family. These specific objections are the cue for the introduction of the expert, who discusses the various methods of getting around the difficulties. On the whole, the same information is imparted by the nutritionist in this setting as in the lecture, but in a condensed form (7-10 minutes) and the same mimeographed recipes are distributed.

A "census" taken in the earlier part of the meeting has shown how many of the women have served any of these foods in the past. Now the group is ready to vote on the question of trying one of these meats in the following week.

4. *Results.*

a. *Collection of the data.* The effect of the lectures and group decisions were tested after seven days. An interview at home with each participant was used to determine the extent to which the foods were served and what the reaction of the family was.

b. *Frequency of servings of heart, kidney, and brains, after lecture and after group decision.* Before the experiments, the frequency with which these meats were served by the participants in the lectures and the participants in the group decision were about equal. In both cases, kidney and brains were very infrequently served. The results of the experiments are shown in Table 19.

TABLE 19—CHANGE OF FOOD HABITS

	Group decision				Lecture			
Economic level	Low	Middle	High	Total	Low	Middle	High	Total
Number of participants	17	16	13	44	13	15	13	41
Per cent of individuals serving one or more of the three meats	35	69	54	52	15	13	0	10
Per cent of individuals serving a meat they had *never* or *hardly ever* served before	20	53	54	44	0	8	0	3
Per cent of individuals serving a meat they had *never* served before	13	36	50	32	0	8	0	3
Per cent of participants serving one or more new meats who had *never* served *any* of the three meats before the experiment	..	..	..	29*	..	..	..	0†

* Out of total of 14 participants.
† Out of total of 11 participants.

Within the seven-day period after the lecture meeting, four women, out of a total of 41 participants of the lecture group, served at least one of the three meats. Out of a total of 44 participants in the group-decision groups 23 women served at least one of the glandular meats. In other words, the lectures led to action by 10% of the participants; the group decision led to action in 52%. Furthermore, after group decision, 23% of the women served a food they had never served before, whereas the corresponding percentage for the lecture group is 3%.

The same trends are shown if we consider each economic level separately: the percentage of women who served a food that they had never served before varies between 13% and 50% for the participants in group decision. For the lecture group, it is zero % for two groups and 8.3% for the other group.

Fourteen participants in group decision had never used any of the three meats before; this indicates that the food was highly negative to them. Twenty-nine per cent of these individuals tried one of these meats in the following week; whereas none of the eleven members of the lecture groups who had never tried any of the meats used them during the seven-day period.

5. *Summary.*

An experiment comparing lecture and group decision methods for change of food habits was carried out with about one hundred and twenty women from varying economic levels in a medium size town in Iowa.

The check-up after seven days showed that when the nutritionist functions in a group decision setting, the changes are definitely greater than when this same nutritionist functions in a lecture setting.

The success with glandular meats indicates the usefulness which this method may have even in cases of strong resistance to changes in food habits.

This procedure is in line with recent attempts at group education in various fields: the individual is approached in a group setting, and democratic discussion rather than lecture is stressed. No attempt is made to manipulate the group by high-pressure sales talks.

It should be emphasized that the procedure described here is not merely a group "discussion," but a *discussion leading to a decision.* In this particular version, this decision has not the characteristics of a "resolution" of the group, although there may be cases where such a decision for group action is advisable. Rather it is a decision made by the individual concerning her own action—the housewife decides what she will do at home. The group setting gives the incentive for the decision, and facilitates and reinforces it.

C. Relation of Group Decision Method to Findings of Interview Study

The procedure reported in Section B contains the following steps (described in greater detail in the mimeographed report): 1) setting the stage; 2) eliminating the possible implication that the problem is typical of a low status group; 3) request for group opinion on the possibility of changing food habits; 4) discussing the particular foods to be changed and taking the census; 5) the nutrition expert answering questions in regard to difficulties of preparation, etc.; 6) asking for a group decision; 7) discussion of method of presenting the food to the family; 8) discussion of determining the success of carrying out the decision.

The content of the discussion seems to have been guided by the same considerations which come up in the interview data. These data suggested that food habits might be changed by changing, for instance, the food channels, the place of a particular food inside or outside the area of consideration as "food for us," the frame of values governing food conduct, the high or low position of a given food on the various value scales.

1. When the discussion leader dealt with the glandular meats in terms of health food, they were automatically placed in the area of consideration as "possible foods for us." For those women who were already somewhat familiar with the health value of this food, its position on the "health scale" was raised.

2. Greater potency was given to the health area by linking health with patriotism. This was accomplished by the explanation of the Government's concern over the number of young men rejected by the army on grounds which might be related to nutrition.

3. The experimental foods, particularly kidney, were placed on a higher status level and perhaps even on a "fuss" level by describing the widespread use of kidney in England.

4. The conflict associated with "low-money food" was removed by combining emphasis on the inexpensiveness of the glandular meats with emphasis on "health" and "status."

5. The obstacles in the path to the goal were removed, either in the discussion or by the comments of the nutritionist. Some of the principal obstacles were:

a. *Buying.* This channel was clarified; the women were told where they could get the glandular meats, that they would have to tell the butcher ahead of time when they wanted them, etc.
b. *Preparation.* One outstanding objection raised by a number of the women was the bad odor of kidneys during cooking. A way of overcoming this and other difficulties were described. Recipes for each of the meats were distributed.
c. *Presentation to the family.* The women discussed how they might best present the new foods to their families. (For instance, one woman reported that she overcame her husband's objection by telling him what it was only after he had expressed his liking.)

6. The group decision had a "freezing" effect for future action. This is an aspect missing in the lecture method. After a lecture many paths are still open whereas after a decision the person has committed himself to follow one path. After the previously existing food ideology had been loosened up in the discussion period and after forces had been created which lead to changes, the decision is the first step toward stabilizing the food ideology in the new pattern.

III. SUMMARY

This study deals with the problem of why people eat what they eat and with certain experiments in change of food habits. Food behavior is determined by the dynamics of the food situation which includes the channels through which food comes to the table, the gatekeeper governing the channels at the various points, and the food ideology of the gatekeeper. A system of values is the basis of some of the forces which determine decisions about food and bring about conflicts of varying intensities.

In the experiments on changes of food habits, a group method, group decision, was compared with a lecture method and request. These experiments suggest that it may be possible to bring about in a relatively short time definite changes in food habits, even in food items which would be expected to show great resistance to change.

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ADJUSTMENT TO DIETARY CHANGES IN VARIOUS SOMATIC DISORDERS *

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This report deals with the influence of psychological factors upon the adjustment to a prescribed diet. The observations were made on children in whom a change of previous eating habits became necessary for medical reasons. Investigation of the family background permitted insight into the factors influencing the child's personality development in general and his success or failure in adjusting to the new diet in particular.

It was hoped that the findings might prove of help in evaluating the psychological factors involved in general nutritional changes due to wartime conditions. Although the reasons for the need of dietary changes are greatly different in a nation-wide rationing program and in an individualized prescription in a medical office, the *common* factor is the circumstance that in both instances individuals, family groups or the whole nation, find themselves confronted with the problem of suddenly giving up customary eating habits, *not* because they have spontaneously changed their taste and appetite, but because they are being told to do so by some outside authority. Different individuals will react differently. It is essential that cooperation is obtained on as wide a scale as possible in order to insure survival in an emergency.

The patients on whom the observations were made were recruited from the Protein Clinic of the Medical Department, and the Diabetes and Epilepsy Clinics of the Pediatric Department. We are greatly indebted to the physicians, dieticians and social workers of these clinics for their assistance and cooperation.

The observations in allergic, diabetic, and epileptic patients were intended to serve as a control to previous observations in a large group of obese children. The obesity study has extended over more than five years and comprises more than 200 children, both boys and girls, who were patients at the Pediatric Department of the Columbia Presbyterian Medical Center in New York. It was found that in all instances food was of central importance for the children and their families. Originally the study had been planned for the purpose of recognizing with greater accuracy the endocrine factors which, according to prevailing concepts, were responsible for the progressive accumulation of fat tissue. Contrary to expectation it was found that instead of the assumed, but unconfirmed, endocrine dysfunction, excessive eating, coupled with muscular inactivity, was the outstanding causal factor.

Viewed as a problem of energy balance it should have been possible to achieve weight reduction simply by reducing food and increasing activity.

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In clinical experience, however, this proves to be exceedingly difficult. There is marked objection to any change in the established habits, which pointed the way to a study of the psychological factors involved in the food habits of these children. It was found that the need for excessive food intake and the fear of activity and social contacts are intricately interwoven with the human relationships within the family circle, the child's personality development, and life experiences. The family frame is such that it does not offer sufficient emotional security to the obese child so that eating serves not only the appeasement of bodily hunger but is also charged with high emotional significance for maintaining a precarious balance in the relationship between the obese child and his mother. Overeating helps the child to combat anxiety and to achieve a sense of satisfaction and comfort, and food is overvalued as the main, sometimes only, expression of love and affection. The exaggerated bodily size in itself becomes of emotional importance. It gives a sense of strength and power to the timid, fundamentally insecure fat child. Interference with the established eating habits, even when asked for by the patient who suffers from his ungainly bulk, is likely to bring into the open the conflicts and anxiety which have been hidden under the cover of the excess fat. A changed eating program can be carried through successfully only after the underlying emotional factors have found consideration. These observations have been published in a series of articles, a list of which follows this report. There have been a number of corroborating publications from other clinics in the United States, Canada, and South America.

For this year's study it had been planned to observe how these fat people, for whom large quantities of food are of such extraordinary importance, would adjust to shortages and rationing. Thus far food restrictions have not been stringent enough to make an appreciable difference in the eating habits of the obese. Eight obese families in Baltimore were contacted and repeated home visits were made to obtain information on their adjustment to the various stages of the rationing program. It is surprising how little interference there has been thus far with their eating habits. None of them had diminished the quantity of food, and the need for replacement of one foodstuff by another (such as rice, noodles and spaghetti for potatoes) was accepted with equanimity. This seems to be due to the fact that obese people generally overeat on carbohydrates which have been plentiful and inexpensive. One might even expect increase in obesity in some cases. There has been an increasing shortage of chocolate and candy and similar products. One may expect changes in the younger group of fat children who generally are overstuffed with sweets, candy and ice cream. The mothers of these children will have to find new ways of expressing or withholding affection. It is planned to continue the observations on the reaction of the obese to rationing and shortages in the previously studied families in New York.

Unwillingness and inability to change faulty eating habits and to accept therapeutic restrictions are present in the obese with such regularity that it seemed profitable to study other groups of patients in whom special and restricted diets are prescribed. The following observations were made in fifteen diabetic, six epileptic, and seven allergic children and their families. This is a small number as compared with the large group of obese children previously studied. The differences in the reaction between the obese and other children with dietary problems are so striking that the observations are sufficient to demonstrate them. The obese children, and even more their mothers, raise objections against dietary restriction with such vehemence and regularity that one might be led to believe that eating habits during childhood are such an intimate aspect of the family life that any interference and necessary changes would prove impossible or exceedingly difficult. In contrast to the one-sided type of reaction of the obese, the patients in other groups showed various reaction patterns. Many showed themselves quite capable of integrating the new eating habits without upsetting their previous pattern of living. In others, some problems of adjustment arose, but only rarely of such central importance as in the obese.

The problems with which the patients in the different groups are confronted, show some differences. The reducing diet for an obese child is usually not different from that of the average child. It is "reduced" only by comparison with the previous enormous intake. Really low caloric diets are indicated only in exceptional cases. All the objections against the hardship of dieting are made against a diet which is normally satisfying. The diabetic diet is similar except that greater exactness is required. The different items are weighed at each meal, carbohydrates are kept low, and exact spacing of the different meals is necessary. There is little variety and eating for special occasions like parties and picnics has to be carefully planned.

The allergic diet is restricted only insofar as one or the other specific item is being eliminated, whereas the quantity is left unaltered. The most difficult diet is the ketogenic diet prescribed for epileptics. Carbohydrates are cut out as far as possible with the use of natural foodstuffs, and are replaced by large amounts of fat which are difficult to eat without bread or crackers as a carrier. Wartime changes added one more difficulty. Heavy cream, which could be offered in the rather pleasant form of whipped cream, is no longer available. The amount of butter had therefore to be increased. The diet is very small in bulk and allows for little variation.

The epileptic is also in a more difficult psychologic situation as to the relation of the dietary change to his illness. These patients come to the clinic because they have convulsions—not a feeding difficulty. Unexpectedly, and for reasons which are difficult to understand, they receive instructions for a ketogenic diet, which is quite unlike what any ordinary child would choose as his food. The relationship to clinical improvement is not always convincing. Sometimes there is no influence at all, or the attacks become only less frequent. In an exaggerated way, these epileptic patients illustrate the difficulties which a previously not-food-conscious group faces when suddenly confronted with the task of adjusting to a strange and unattractive diet without a clearly recognizable goal. In spite of all the difficulties, the experience of the Epileptic Clinic shows that quite a number of families are capable of carrying out the prescription. For external reasons, there are only two "cooperative" cases among the six families whom we could study. Analysis of the material shows that the frequent inability to accept the diet has as much to do with psychological factors within the total setting as with the difficulties inherent in the diet.

The relationship of the diet to the complaint problem appears more obvious in the other conditions. In allergy, the elimination of the specific precipitating substance may bring about freedom from distressing symptoms, a relationship which can be experimentally verified by the patient by eating this food. In the diabetic, the dietary restrictions seem to stand in a direct relationship to the sugar excretion, and digression from the calculated diet may be followed by recurrence of serious symptoms. Even if preoccupation with food was not present before the disease, careful attention to eating may be expected in these families since serious complications, even death, may follow non-adherence. Although severe degrees of obesity may be just as disastrous for a child's development as the dangers which beset the way of the diabetic, the need for treatment is generally accepted with less seriousness by the obese family. The close relationship of faulty food habits to the development of the condition is quite obvious to the outside observer, but often vehemently denied by the fat child and his parents. It is this group which offers the greatest difficulties in changing eating habits which in themselves are an expression of their emotional dissatisfaction.

As was stated before, non-obese patients with dietary problems are capable of accepting a new diet as part of their total living. In contrast to the central food problem in the obese, these other patients show that dietary changes may serve different psychological functions and are integrated accordingly. Common to all patients is the expectation of complete cure after some time. Working under the concept of a time limitation for the restrictions seems to be one mechanism which helps in making it possible to tolerate a strictly supervised régime. It was previously observed in the obese group that results of treatment were better when the patients were seen at weekly intervals with a definite goal of what was expected of them for the coming week.

The material at hand allows a division into three groups who handle the task in different ways. Since most observations were made on diabetic children, the following discussion is based mainly on the reactions of this group. In addition to the restriction of the diet, the diabetic children have to contend with repeated daily insulin injections, urine tests, frequent trips to the clinic, and other burdensome tasks. There seems to exist a fairly accurate parallelism between the way the diet and the other problems are handled. The first way may be described as one of *intellectual acceptance* of the new situation with good, though not rigid cooperation. There may be, in the beginning, confusion and anxiety until all the details are understood and can be handled with ease. The second group is even more cooperative. Adherence to the diet is more than fulfillment of a task for a definite physiological reason. It becomes endowed with a magic power of its own. The concept of reward and punishment plays a great role. There is strictest adherence to the new diet and obsessive features are quite marked. One might call this a *neurotic integration,* most often with an obsessive pattern. The third group is "uncooperative;" that means these patients experience marked difficulties in following the dietary prescription. In many ways the problems of these patients resemble those of the obese. The changes in the eating habits seem to upset their whole pattern of living. As in the obese, the whole issue centers around an ***unresolved dependent relationship*** to the mother, in which offering and receiving of food plays a paramount role. It is not astonishing that some of these patients had been frankly obese or showed tendencies in that direction.

The number of observations is too small to allow for figures of frequency and distribution. An intellectual acceptance without serious interference in the total personality development is certainly not rare. All the various tasks can be handled quite well, without a feeling of undue hardship and deprivation, if the fundamental emotional relationships are sound. In some families the manifold tasks make for greater closeness between the mother and child and a spirit of teamwork develops. Sometimes the family as a whole adjusts its eating habits to the prescribed diet, to make it easier for the patient—and this is done without resentment against him. Although these families are aware of the gravity of the condition, the new diet is not enforced with a threat of death if broken in some detail. There is appeal to "it is good for you," particularly with younger children. Generally food had not been misused for discipline before the onset of the illness.

A representative case is that of a seven year old girl, the youngest child in a farmer's family. She had become sick, following a short febrile disease, about a year and a half ago. The mother tells how they were disturbed when the nature of the little girl's illness was first discovered. "It struck us like a thundercloud." Now she speaks quite objectively about her way of handling the situation. When the child came home from the hospital after the initial standardization, the two older brothers of high school age helped her with weighing the diet and calculating food exchanges. Now the girl herself takes active part. To the mother, the numerous small tasks were nothing new, since she had nursed her own mother during several years of sickness. That was part of her position as the youngest daughter who had stayed on the farm and whose husband had become the new owner. She speaks with warmth of the good relation of the patient to her older siblings, how they all like the little girl and helped out when she became sick and hospitalization was necessary. The girl is not self-conscious about having diabetes; she is as active socially as before and feels in no way slighted because she has to eat according to a prescription. The mother tells with amusement how the girl runs to the drugstore to get her an ice cream cone to prevent the mother's giving it up in her behalf.

In a number of these families there are more initial difficulties or in others the relationships are not as smooth. Sometimes the loyalty to the clinic which has helped in the present and past emergencies is the incentive that makes some patients adhere to a diet which would be too difficult a task otherwise. So we may find children with behavior difficulties in this first group, without food becoming a focus for their problems.

In the second group there is very strict adherence to the diet with much anxiety about the slightest deviation. The concept of "cure" plays a great role, not in the way it was observed in all cases that there should be a time limit to this strict supervision, but in the definite feeling that a cure will come as a reward for goodness. The task is not seen in relation to the disorder but as magic that will bring about cure if all rituals are carefully attended to. The slightest deviation arouses anxiety because it means that the magic has been spoiled. Changes in the régime are difficult to accept for these patients.

One boy of 15 is characteristic of this type of adjustment. He is most painstaking in weighing his diet and refuses any other food like poison. He follows his diet with greatest accuracy, but if there is a trace of sugar in his urine, "he worries and worries about how it could have happened." To him it is not a question of practical adjustment but one of justice, and he feels depressed and insulted because he does not get the just reward that is coming to him. The boy has shown obsessive features in many other ways since early childhood. He was always neat as a pin and he is so fond of cleaning and scrubbing that his mother says of him, he should have been a girl. In this boy the diabetes became manifest at the age of 13 when the father suddenly left the family and married another woman. This boy had been particularly close to his father, an attachment that went back to the time when his younger brother was born. He was so jealous that he did not want to speak to his mother. "I am Daddy's boy. Mother has another baby!"

In other cases of this group it is the mother's obsessiveness that endows the diet with a magic function. Other children compensate for their rigid goodness by bad behavior in other respects, like petty stealing or showing off in school. There is generally much embarrassment about the disease with an attempt to hide all emotional reactions to it.

Both these groups are comparatively simple from a medical point of view. Once they are standardized, minor changes and adjustment will keep the metabolic condition under control. They may be sent to the psychiatrist for behavior disturbances which stand only in an indirect relationship to the diabetic condition.

The third group has difficulties in accepting the diet from the start and makes an adequate control of the diabetic disturbance practically impossible. In addition, these children are in a constant emotional turmoil which in turn has an effect on the sugar excretion. They are constantly in and out of the hospital. After careful adjustment, the sugar excretion becomes unbalanced again as soon as they go home. Fortunately cases with such serious emotional disturbances are not frequent. There are only two among the fifteen diabetic patients. Both boys were unable to adhere to the dietary restriction not because the prescription was more severe but because the total life situation lacked security and emotional support. One of these boys has since developed a schizophrenic reaction. Even in the hospital situation he would deliberately break his diet, generally in a petty way, apparently to demonstrate that he was not being controlled by anyone.

That adequate dietary control is possible in spite of severe conflicts in the family background, was demonstrated in one case of epilepsy where the mother received psychotherapy during the period when the child was being treated by the ketogenic diet. In spite of all the inherent difficulties, she became capable of handling her very unruly and aggressive child with calm and kindness so that he accepted the diet from her without objection. As the relationship improved he became less aggressive and wanted to show his affection to her which generally assumed the form of his taking the best looking fruits and other food from his grandmother's pantry (the grandmother had been a most disturbing factor), with the intention of bringing it to his mother.

If one tries to correlate these observations with the problems which face the population at large, one might draw the conclusion that people who are reasonably secure and constructive in their outlook on life will be able to accept a wide range of changes and limitation in their eating habits. One might expect that which we call intellectual acceptance as the normal pattern, whereby slightly panicky and confused reaction will occur in the beginning until the principles and aims are mastered and understood. In some instances there may be a neurotic, obsessive acceptance, with fear and panic and expectation of magical help. This type might become upset about minor changes and variations. These might be the people who become anxious about the point rationing system with its fluctuating values from one month to another. People who react in the way the third group of our patients do, have to find the same type of consideration as other sick people in a program of this sort. People who really cannot adjust to prescribed changes in their eating habits will need special consideration and treatment just as people with organic disease.

This report has been written with the full awareness that the work raised new questions instead of answering them. It needs continuation in different directions, partly in an attempt to evaluate the direct reaction to food rationing, and also in the more strictly psychosomatic aspects. The study of non-obese patients with food problems was carried out for the purpose of gaining an understanding of the underlying personality structure in different organic diseases. By focusing on their adjustment to the dietary changes a very slanted picture was obtained, yet sufficient of a picture to show, e.g., that the diabetic patients are a different and less uniform group than the obese. Further work for the delineation of the various features is indicated. Another plan for future work will deal with the effect of food deprivation in infancy and its relation to affective security and to later personality development. The observations of this year's study suggest that the emotional security of the home may go a long way to counteract harmful effects of deprivation and restrictions.

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A STUDY OF THE USE OF THE FRIENDSHIP PATTERN IN NUTRITION EDUCATION *

Earl Lomon Koos

The Purpose of the Study

One of the urgent needs in health education, and especially nutrition education, is for channels through which information can be diffused into the population. This need is especially urgent in the low income urban areas where many factors militate against active participation by large numbers of the population. Not only do sheer numbers of people and the great need for information add to the problem, but certain contributing factors are present.

The most obvious of these is the physical condition of living to which the low income urban dweller is subjected. However, the tenement is not only a particular kind of building—it is also "a way of living, a whole series of habits, attitudes and sentiments." From this way of living a *narcotization* results which renders the less able portion of the population insensitive to social stimuli. A second factor is the lack of education which enables the individual to cope with the problems of a complex urban environment. The cultural heritage of the foreign-born and of the native-born-of-foreign-parents provides a further handicap since many of our foreign-born come from those areas which have had the least contact with modern ways of living. The fact that the transplanted cultural heritage rarely has a chance to be wholly old- or new-world has a bearing here.

The difficulty for the low income family of living in a money-centered culture adds to our general problem. The sense of security which comes from "making a living rather than earning it" is lacking and the family suffers accordingly.

Attempts to set up channels to these groups have usually taken one or another of three approaches: first, a spatial approach, such as the block plan; second, an organization approach which sets up a super-organization to dictate policies and procedures to existing organizations; third, by artificially constructed groups through which information is distributed. The first of these seemed undesirable since it has been determined empirically that association tends to form without regard for area limits. The second appeared weak in that it depends upon the strength of individual personalities and their ability to finesse vested interests against each other. The third often failed when initial enthusiasms had waned and left a residue of discouraged participants.

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* An experiment undertaken by the Department of Public Health and Preventative Medicine of Cornell University Medical School in the Kipps-Bay Yorkville Area of New York City, with a grant from the Committee on Food Habits, National Research Council.

A study of urban life shows that the old feeling of belonging to or being identified with a particular neighborhood has waned. It is known, however, that associations between individuals, and families, continue and that these associations can be recognized as structures in the social pattern. The possible utilization of these "friendship patterns" as a channel for diffusing knowledge, and as a possible channel through which the low income group can express its needs, was the primary purpose of this research project. A second purpose was to ascertain, in the brief time allotted to the project, something about the social patterns of the nationality groups and the place of nutrition in these patterns.

THE TECHNIQUES EMPLOYED

Potential leaders were first picked from among the women known to settlements and other agencies as leaders in community life. This was done because of the brief time element. These women were asked to invite five or six friends to a "nutrition luncheon" as guests of the leader. The luncheon was carefully planned to include as much nutrition information as could be put into the preparation and demonstration of one meal. The purpose of this luncheon was twofold: it was obviously bait to attract women into the group but it had a folkway similarity in that it appealed to the "breaking bread with friends" idea current among this group. Its second purpose was to interest the women in nutrition and to make them a continuing unit in that interest. This first contact was to be followed by conferences of the group, closely following the outline of nutrition courses then being offered in the area. Also, the nutritionist was to continue as consultant to these women through the course of the project. As their contribution the women were asked to bring in menus and keep accurate shopping lists for the period of participation.

Case studies of the participating families at the beginning and the end of the project were to be made by the sociologist. An evaluation of the changes taking place between the beginning and the end of the project and a study of the patterns of friendship in relation to the natural areas and nationality distributions would enable us to learn the degree of effectiveness of this type of teaching.

The ability to widen the effectiveness of such a program depends upon the fact that Mrs. A around whom the first group was built, invited Mrs. B, C, D, E and F to participate. Each of these women, in turn, had a set of friends not identical with those of Mrs. A; therefore each was potentially the center of another teaching unit. This widening of the circle of effectiveness would make it possible to reach a cross-section of the families in any one natural area of the city. For experimental purposes, however, groups from several areas were to be chosen to show more clearly the results of such procedures and so that the coverage of several nationalities might be facilitated.

THE OPERATION OF THE PROJECT

In all, 177 housewives were contacted in the course of the project and only 12, or 6.7%, refused any cooperation whatever. One hundred and forty-four, 81.5%, of the total number refused to cooperate to the extent of having a luncheon, but discussed one or more phases of the nutritional pattern with the staff. Fourteen, or 7.8%, gave the luncheons and 7 others, or 4%, agreed to do so but later failed to carry out their agreement.

Of the 144 housewives who refused to give a luncheon, 52, or 36%, expressed an interest in doing so but were sure their friends were not sufficiently interested in nutrition to participate. It was our impression that this interest was in large measure a spurious one, since only 4 of these women had previously availed themselves of nutrition courses. Twenty-nine, or 20%, stated that they were unable to participate in the project because of either part time or full time employment. An additional 26, or 18%, regarded their home duties as too strenuous to allow such participation. It was our impression that this reason originated more from the concept of the role of the woman in the low income home than from actual pressure of housework. This was substantiated in part by the fact that these women appeared to experience little difficulty in shelving home duties when more interesting activities were available. Only 9, or 6.3%, admitted that they were not interested in learning about nutrition.

The remaining reasons assigned for refusing to cooperate were for the most part genuine and account for only 20% of the cases.

Only 3 luncheon units were carried through the complete schedule. Two units, both Italian, were composed of relatives of the hostess, and these, together with 8 others, did not return for follow-up conferences. The remaining luncheon (Hungarian) failed to attract any of the guests who had accepted. This failure to cooperate seems to have its genesis in certain factors in the urban culture which have been mentioned in the Introduction. The follow-up study of the failures indicated that neither the structure of the project nor the methods employed by the nutritionist were at fault, since both were acceptable to the participants.

THE FRIENDSHIP PATTERNS

The configurations of the friendship patterns showed in only one instance a block pattern. They tend for the most part to confine themselves to the natural areas of the city and any of the friendships which cross these boundaries appear to be the results of earlier associations.

Figure I shows graphically the spatial distribution of the members of an Irish friendship pattern. It should be noted that none of these luncheons drew guests from within any one census or social block; they were confined, however, to the same natural area in the city. The sole exception was one guest at the third luncheon, a childhood friend of the hostess, who lived some fifteen blocks away.

The second factor in determining the configurations of the friendship patterns was that of adherence to a local organization.

The friendship pattern of the Irish group illustrated in Figure I is shown in Figure II as it relates to the Mothers' Club in a local Catholic church. It will be seen that with the exception of persons Nos. 6 and 14, all of the

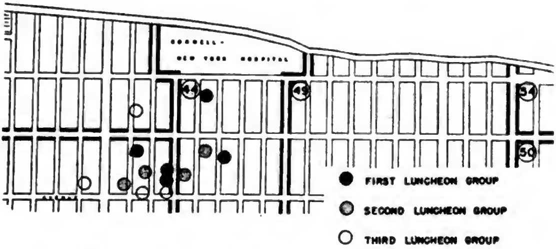

FIGURE I.—Spatial distribution of an Irish Friendship Pattern.

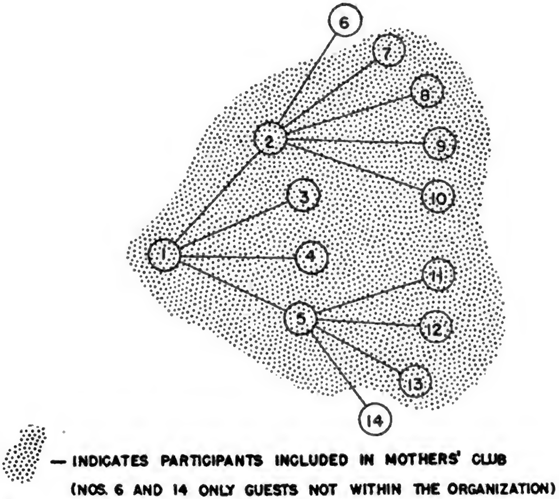
1
2
3
4
5
6
7
8
9
10
11
12
13
14
— INDICATES PARTICIPANTS INCLUDED IN MOTHERS' CLUB
(NOS. 6 AND 14 ONLY GUESTS NOT WITHIN THE ORGANIZATION)

FIGURE II.—Relationship of Irish Friendship Pattern to established organization in the community.

luncheon participants were found inside the shaded area which represents the aura of the Mothers' Club.

The tendency of native-born-of-foreign-parents to mix nationalities in their friendship patterns is seen in this project. The foreign-born hostesses invited only guests of their own nationality (and significantly from within their own organizations), whereas the native-born hostesses failed to exercise such choice. In the case of the Irish pattern illustrated in Figures I and II, the first luncheon entertained 2 Irish and 2 Hungarian guests, the second, 4 Irish and 1 Czechoslovakian, and the third (a Hungarian hostess), 1 Irish and 3 Czechoslovakian guests. This pattern of isolating or mixing nationalities in the friendship patterns has its chief significance in the idiomatic food patterns, which are discussed in a later section.

IDIOMATIC FOOD PATTERNS AMONG NATIONALITIES

The nationalities comprising the population of this section of New York City are intermingled. Few tenements have residents of only one nationality and this intermingling apparently has done much to break down the idiomatic food patterns. While the foreign food patterns persist, there is apparently a modification of the native diet. (The stores supplying foods for particular nationalities have less of the special foods associated with particular groups than is the case in some other parts of the city. A special shopping study with volunteer workers was undertaken to ascertain this point.) Examples of this modification are found in Italian families where the housewives indicate an increased use of potatoes and rice, with a slightly decreased use of spaghetti.

Of all the established diet patterns which are brought to this country from foreign cultures, the pork-potato-cabbage-tea pattern of the Irish appears to continue with greater tenacity than does any other diet pattern. Several Irish families which are two generations removed from foreign-born stock continue in this pattern, and it is a matter of some pride in the family. This accompanies an identification with "the ould sod" which seems to persist longer in the Irish families than in other nationalities. There are, however, remnants of this pride in a nationality diet in most of the other groups.

The heavy diet of the meat-potato-vegetable variety which is enjoyed in the central European countries continues here. The Czechoslovakian, Hungarian, and German families studied all report adherence to this pattern. They do, however, admit to a greater choice and variety of food than was utilized in Europe. Regardless of the caloric requirements of the individual, these groups consume quantities of heavy food, even when in straitened economic circumstances. In this group, as with the Italians, food is mentioned repeatedly as being eaten for enjoyment. A further demonstration of the high esteem in which these groups regard food is evidenced by the fact that it is rarely used as a psychological weapon for forcing obedience or for the punishment of children. Likewise, the families studied in these nationalities exerted less pressure upon the children to eat particular foods than do the Irish.

Certain of the ideas and patterns idiomatic to these nationalities appear to have sloughed off or are in the process of disintegration. Faced with new patterns of food distribution and food preparation, many housewives have found it expedient to forego established practices in food preparations. The Italians' increased use of canned and other prepared foods is an example of this. Nutritionists have told us that except for tomatoes and tomato paste, the Italian woman regards tinned food as an abomination. In a majority of the Italian homes, however, we found tinned food of other varieties, and prepared cereals were in general use.

The influence of the school lunch, of the factory cafeteria meal, etc., is felt among these families. Many reported some event or circumstance outside the home which caused a new food to be adopted, or an old one to be dropped from use. This was especially true where late adolescents were in the family and certain foods had a high value for their status giving qualities.

FACTORS INFLUENCING THE FAMILY'S NUTRITION PATTERN

The nutrition patterns of the families studied appear to be influenced by two sets of factors—those inherited from the past and those operative in the environment. The relative weights of the two vary from family to family and from nationality to nationality but a few are found consistently.

The first of these is the status giving quality of certain foods. A major portion of the low income families we have studied came from European peasant stock, and therefore had been confined to less varied and more simple foods than are available here. Foods which in our culture have only utility value carry in European cultures a connotation of wealth and position. The ability to buy meat at all times, and even on limited budgets, is status giving and is not likely to be relinquished without adverse effects. The same attitude seems to hold for white bread. Only a few families admitted the use of whole wheat breads, and less than 10% used enriched white bread. The identification of whole wheat bread with the dark breads of low income European diets militates against its acceptance. This attitude was so usual about meat (especially beef) and bread, that it offers a clue as to reasons for rejecting contemporary nutritional teachings. A summation of this idea is represented in the statement of a Polish woman (not in the present group) who was asked her reasons for not enrolling in a nutrition course: "Why should I take a course—those teachers just want you to do things a certain way. In Poland we had to eat a certain way—it was all we had to eat. Here we can have what we want to eat—why should I let her (the nutritionist) tell me what to eat and how to eat it?"

This desire for freedom of choice, and especially to choose those foods which are symbols of status, appears to be so universal among the low income groups as to warrant consideration by nutritionists when planning low income courses. The outstanding example of this lack of consideration is the resentment our respondents expressed at being told to eat the cheaper cuts of meat. Our nutritionist was careful to avoid this mistake, but resentment on this point was generated by current advertising and by the publicity of agencies and industry.

In addition to the symbolic values of certain foods, the unregimented use of foods appears to have a "release" value. Whether or not the respondent buys wisely or prepares the food well is not important here—the important thing seems to be that choice and the ability to "splurge" on food provides a psychological release from the problems of urban living.

The buying patterns of these families vary greatly as to place and time, but they are confined largely to day-by-day buying. Most of the women recognized the value of quantity purchases and of planned purchasing, but the physical environment prohibits storage of perishable and bulky foods. Meal-by-meal buying has a psychological value, too, for many of these women, since it provides an excuse for getting out of the tenement. Here again a conflict exists between the low income consumer of nutrition information and the nutritionist whose orientation, in the main, is not toward the low income group.

The fact that the number of prepared foods has increased greatly in recent years, coupled with the physical limitations of the low income homes, seems to have an effect upon the nutrition patterns of these families. Overcrowding is so universal, and housing conditions in general are so poor, that the utilization of things which make the task of food preparation less complicated is understandable. Here again it seems to us to be necessary for the nutritionist interested in implementing a program to consider the nutrition patterns as single facets in the whole problem.

The cultures out of which our respondents have come, either directly or one generation removed, have stressed the sanctity of the home and have emphasized its place as a training center for living. From this has come the practical attitude that "what we did at home, what we were taught, is right," even when forced adjustments to the present environment are made. Eighty-nine respondents mentioned the strength of this influence when discussing reasons why they were not affected by nutritional teaching. However, this resentment seemed to arise only when the food pattern as a whole was attacked. When pressure was exerted on isolated items in the diet, a more favorable response resulted. The educational campaign for increased use of milk, for example, has occasioned less resentment than the "You Must Eat These Five Foods Every Day for Health" campaign recently instituted. The former is additive, and therefore not necessarily destructive of values inherited from the past.

SUMMARY

Our original premise included an indictment of the "block plan" and of the "organizations" plan, with the assumption that the natural friendship pattern would be more effective for diffusing information on nutrition. This assumption seems unwarranted in view of the fact that the destruction of the peer-nature of the friendship pattern, or the introduction of an ulterior motive, tends to render ineffective this pattern.

The fact that friendship patterns operate for the most part within the confines of existing organizations suggests that strong local organizations can be utilized as channels for the diffusion of information. The fact that the urban culture is crowded with organizations which overlap spatially seems to indicate a possible coverage that would be adequate.

The wide variety of foods available to the low income family, the interdigitation of nationalities, and the pressure of American institutions on the family through the children and through industrial and social contacts, have all tended to weaken the idiomatic food patterns.

The psychological value gained from the use of certain foods and in particular ways is greater than are the benefits from the usual nutrition course. Unless the nutritionist is willing to recognize these factors, the effectiveness of her work with the low income group is doubtful.

A STUDY OF THE EFFECTS OF ODD-SHIFTS UPON THE FOOD HABITS OF WAR WORKERS

GLADYS ENGEL-FRISCH

Changing occupational rhythms are bringing about changes in the food habits of war workers throughout the country. In February of 1942, 40% of all war workers were on atypical work shifts A study of 108 war workers in Seattle and Bremerton, Washington, attempted to answer two broad questions concerning the effects of these atypical shifts: 1) what are the implications for food habits of working on one of the two atypical work shifts; 2) what indications are there of ways in which these dislocations in food habits could be compensated for if the effect is found to be bad, or taken advantage of if the effect is found to be good? Seattle and Bremerton, being typical defense boom towns, present pictures of the problems facing the average odd-shift worker.

Shifts are generally spoken of as the first, second, and third shifts. In general, the first, or day shift, starts between 6:30 a.m. and 8:00 a.m. and runs until 3:00 p.m. or 4:30 p.m. The second or swing shift begins when the day shift ends and ends about midnight or 1:00 a.m. The night or graveyard shift begins at the end of the swing shift and ends at the beginning of the day shift. While hours on the odd-shifts differ for the individual workers, they are similar enough so that one can speak of *the* swing shift worker or *the* graveyard shift worker.

The average odd-shift worker in the study was found to be male, only one government shipyard and one aircraft company hiring women for manual jobs. He is on the average 31 years of age, and there is better than an even chance that he is married. If he is married, chances are four out of five that his wife is not working. He probably has one child and this child is most likely to be of pre-school age. The worker is engaged in manual activity and most likely he has come to Seattle or Bremerton within the past year. If he is employed as an aircraft worker or in a private shipyard, he is a union member.

He probably has worked on the day shift all his life. Although he is now on an odd-shift, there is almost an even chance that he still prefers the day shift. He decidedly prefers the swing shift as opposed to the graveyard shift. Advantages relating to sleeping appear to be the reason he will most often give for preferring a particular shift. Two groups of responses, those relating to sleep, and those relating to advantages of both sleeping and eating, constitute almost one-third of the total reasons given for preference. The advantage of sleeping late in the morning appears to be a significant reason for his preference of the swing shift over the graveyard shift. However, when both advantages as to sleeping and eating are considered, he definitely prefers the regular day shift to either odd-shift. The day shift is "natural" to him.

The older he is, the less likely it seems that he will prefer the graveyard or swing shift. If he is over 35, there is a greater probability that he will prefer the day shift. If he has worked only the graveyard shift, he is less likely to prefer the graveyard shift than he is to prefer the swing shift if he has worked only swing shift. He decidedly does not like the idea of alternating shifts, especially in short time intervals, because of the amount of time (at least one month) which it takes to adjust to a new shift.

Place of employment (aircraft, private shipyard, government shipyard), type of domestic arrangement (with family, rooming, batching, boarding), type of work (clerical, manual), and length of time on the shift, are found to have no significant relationship to his adjustment to the odd-shift.

In comparing adjustments made in food habits on the two principal types of odd-shifts, food habits are found to be integrally related to sleeping habits. Although there is no significant difference in the number of hours of sleep the typical graveyard shifter gets as compared to the number of hours of sleep of the average swing shifter, the lower average hours of sleep of the night worker is found to be suggestive. Over one-fourth of those on the graveyard shift sleep less than seven hours a night while only about 4% secure that little sleep on the swing shift. Sleep on the graveyard shift is often broken and restless because of daytime noises.

On the swing shift, the arrangement of sleeping hours is almost unanimous, with 80 of the 86 swing shift workers sleeping during the night following their return from work. The graveyard shifter may either sleep during the daytime following the return from work or split his sleep into two parts. The swing shifter is less apt to eat before sleeping than the graveyard shifter and while his typical "retirement" meal is a snack, that of the night worker is breakfast.

The odd-shift worker averages about three and a third meals per day. The only "normal" meal neglected by the worker on the night shift is breakfast. There is a substitution of snacks for regular meals among the swing shifters, about 16% not eating dinner, and 11% skipping breakfast. Where breakfast and dinner are eaten by the graveyard shifter, they are, in general, eaten at the time of day usually associated with these meals. On the swing shift, each meal appears to be, on the average, about three hours later than is usual on the day routine.

The worker attempts to adjust his food habits to the "normal" day with as little substitution and change as possible. The swing shift sleeps during the night, following the usual pattern. If he eats before he retires, he eats a snack as most people will do in the early morning hours. Upon waking, since it is morning, and since he has just risen, he makes his first meal breakfast. If he eats about noon or later in the afternoon, the next meal, because of the time factor, is more likely to be lunch or dinner. Likewise, the graveyard shifter makes his first meal in the morning (if one is eaten) breakfast. He then sleeps and wakes for the family dinner in late afternoon. While a few odd-shifters substitute breakfast for dinner, or vice versa, in general, workers on both shifts attempt to fit their new occupational rhythms to the old one. Time of day, because of tradition, is the most important factor determining what kind of a meal will be eaten, except in the case of the meal eaten at the plant where tradition alone determines the meal to be eaten. Since traditional times of eating are most changed in the swing shift, food habit adjustment is more difficult on that shift than on the night shift. Estimation is that from one-half to three-fourths of the odd-shift workers lack proper nutrition, but there is no significant difference between the two shifts. More swing shift workers eat by themselves than do those on the graveyard shift.

Complaints and suggestions from the worker center about cafeteria conditions, lengthening of lunch periods, variety in box lunches, the need of nursery schools, and family relationship problems precipitated by odd-shift conditions. He does not think a 15 minute lunch period is long enough, although a half-hour appears to be sufficient. He gets tired of the lack of variety in his box lunch, and wants a hot meal on a cold day. A cafeteria, to compete with the box lunch, must serve varied, tasty food at a reasonable price, in the short lunch period. Family problems arise when children work on different shifts than the father, where his wife is on another shift, and when there are small children whose sleeping habits differ from the worker's. Nursery schools were suggested as a part solution of the problem.

Problem areas, then, center about these points: poor plant cafeterias; no cafeteria; poor restaurants in the plant area, often inaccessible; lack of eating facilities for the graveyard shifters; failure of older workers to adjust eating and sleeping habits to odd-shift requirements; difficulty of food habit adjustment on the swing shift; difficulty of sleeping adjustment on the graveyard shift; nutritional deficiencies on both shifts; interference of recreational needs with physical needs, and vice versa; family problems caused by the new occupational rhythms.

Recommendations called for include: at least a half-hour period, preferably with pay, if efficiency is actually found to be speeded by the longer period of time; adequate cafeteria service for all shifts; sale of well-balanced lunches in plants; nutritional education for heads of families and of boarding houses; an industrial policy of putting older men on day shift except where odd-shift is specifically requested; pooling of information concerning daily schedules through governmental studies and trade-union workers, followed by suggestions to workers; cooperation between agencies interested in recreational and food habits; segregation of workers on separate shifts, where possible, in boarding houses and in governmental defense housing projects; well-equipped, adequately staffed nursery schools for small children; careful consideration of requests for shift change where reason centers about shift status of other members of the family.

Trends in hiring at the present time point to an increasing number of women entering industry as the war continues, an increasing proportion of older men remaining in industry as young men are called to active military service, and an increasing proportion of workers on odd-shifts as war industries become continuous-process industries. Recommendations given here, if worked out, should make the changes necessitated by these trends easier and more efficient in the making.

A SUMMARY OF AN EXPLORATORY STUDY IN FEDERAL EMPLOYEE TURNOVER IN WASHINGTON WITH SPECIAL ATTENTION TO LIVING HABITS *

VIRGINIA VAN DYNE FLEMING

One of the most striking characteristics of Federal workers' lives is the impersonality, the lack of friends, the tendency to like or dislike living in Washington in terms of the city rather than of identified individuals within it. This depersonalization of life makes the individual particularly subject to the impact of impersonal annoyances such as housing, transportation and restaurant conditions.

Other findings in this descriptive study of women Government employees † are that meals are often eaten alone, are rarely considered an opportunity to meet a friend, and are frequently inadequate. The typical daily diet shows an outstanding deficiency in milk and in eggs, and to a lesser degree in other food categories. On the other hand, meat is eaten generally twice a day, and an average of two cups of coffee is consumed.

In addition to the rising cost of living which is a serious problem to most of the subjects, especially those supporting dependents, other problems are the crowded, unpleasant housing, the lack of friends, and lack of knowledge about any of the social opportunities in Washington.

Recommendations in regard to the work situation are that interviewing and counselling be used much more frequently so that workers may be given help with their problems before they reach the point of quitting, that employee suggestions be requested and used wherever possible, that inefficient workers be weeded out and replaced by fewer, better-trained employees at higher wages, and that every attempt be made to add to the worker's feeling of personal security. Recommendations for eating are that the use of attractive substitute dishes for meat be encouraged, that the cost of milk and coffee be equated, and that arrangements be made so that workers can lunch with their friends. It is also suggested that housing be selected with reference to work address, that actual publicity be given to the various opportunities in social groups, and that stores be urged to stay open more than one night a week and give preference to the workers at that time.

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* See mimeographed report of Committee on Food Habits, National Research Council, May 1943, under same title.

† Based on intensive interviewing of thirty-seven women Government employees by three trained interviewers.

QUALITATIVE ATTITUDE ANALYSIS

A TECHNIQUE FOR THE STUDY OF VERBAL BEHAVIOR

RHODA MÉTRAUX
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Since early February 1942, the Committee on Food Habits has been preparing a series of qualitative studies of consumers' attitudes toward changes in the food situation and toward some of the programs initiated by the Government to meet the resulting problems. These studies have had as aims 1) to gain insight into current attitudes, 2) to aid in predicting future trends of reaction, and 3) to discover some of the appeals which could be used most effectively as incentives to cooperative action. The present paper deals mainly with the technique of analysis and the premises on which this technique is based.

I

"Words are part of action and they are equivalents to action." * That is to say, language—communication—is a form of behavior which has its meaning within the context of a specific culture and of specific situations within the cultural framework, just as does any other. Studies of verbal behavior are valuable, not because one can predict that, having said something, a person will merely *say* something else, but rather because it is likely that, having said something, a person will *do* something. And the two, saying and doing, are related actions. Words here have in part an initiatory force, a directive power. For this reason it is essential to the success of any cooperative enterprise that the participants "speak the same language." When, in a new situation, behavior patterns are modified as the result of new experiences, the meaning of words likewise is modified. Cooperative action on an adult level will then be possible only to the extent that the modifications are understood and accepted by all those involved.

Changes in the production, distribution, and availability of food resulting from the war have brought about a new situation in the United States, especially as far as the consumer is concerned. Although certain aspects are familiar to many individuals and groups, either through personal experience or through reports, nevertheless the present combination of circumstances has created what must be considered a new complex. It is to be expected that varied reactions to any single event will occur and that these will be variously interpreted, especially in the earliest stages of change, but, assuming a basic cultural unity, that differences of reaction will be more often (although not altogether) of degree than of kind. Understanding of both types of variation and of their relative importance is essential to the effective planning and smooth operation of any food program. One of the basic problems of leadership is that of making the situation intelligible, of aiding in the realignment of forces that lead to cooperation and efficiency. As in any emergency, it is necessary in the first place to work with the materials, the beliefs and concepts already existing, and the skills that exist or develop. Hence it is necessary to have a constant stream of information about how the people affected react, what older associations they call upon to meet the situation, where the positive strengths lie and how these are used, and where and when negative behavior limits the ability to cooperate and whether this is due to faulty understanding, incomplete knowledge, confusion or substitution of goals, etc. In this connection, studies of verbal behavior are particularly useful because they can be carried out on a comparatively large scale within narrow time limits and because they can give direct insights into associations and symbolism, that is, into the emotional and conceptual background of behavior. Studies of verbal behavior may be validated by comparisons with other types of behavior analyzed at the same level.

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* Malinowski, Bronislaw. Coral gardens and their magic. London, Allen & Unwin, 1935. Vol. 2, p. 9, et passim.

Since no single event, but a series of interrelated events is involved in the development of the various food programs, studies of reaction must have a definite predictive value. Consequently, not opinions as such, but the underlying attitudes must be the subject of study. Since the process of change is continuous, although now one aspect and now another may be highlighted, the method of study must be of a kind in which data can be assembled and analyzed rapidly and which allows a continuous comparison. Finally, since no single group but rather the total population is affected, the aim of the analysis should be to obtain a dynamic synthesis.

II

None of the current methods of opinion analysis quite fitted the purpose which the Committee had in mind. For example, a statistical approach seemed unsuitable to qualitative studies where the emphasis was not to be on, "How much?" or, "How many?" but rather on, "In what direction? In what relationships? With what implications?" Because of staff limitations, it was necessary to depend largely on volunteer assistance in obtaining data from different areas of the country. This meant that the samples obtained might vary in size, but that a variety of skills could be called into action for obtaining data. A number of the collaborators available were highly skilled; the majority were students working under the direction of social science departments of colleges and universities; in addition, a number of other individuals or whole groups could be asked to help from time to time.* A technique was therefore devised which did not require the use of a fixed population sample, which could make full use of the varied skills that were available, and which, to some extent at least, fulfilled the requirements of the aims described above.

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* Grateful acknowledgment is made to all those who gave so unsparingly of their time and energy in the collection of the data. We are especially indebted to the student squads who worked under the able leadership of Dr. Norma Bird of American University, Washington, D. C., Mrs. Florence Booth of Wayne University, Dr. G. Gordon Brown of Temple University, Professor Gustav Carlson of the University of Cincinnati, Dr. Paul Cressy of Wheaton College, Dr. John Gillen of Duke University, Dr. Elton F. Guthrie of the University of Washington, Mrs. Jane Hanks, Dr. Weston La Barre of New Jersey College for Women, Mrs. Ethel McCormick, Miss Dorothy Johnson of the University of Michigan, Dr. Clyde Kluckhohn of Harvard University, Miss Helen Lockwood of Vassar College, Dr. Edgar A. Schuler of the State University of Louisiana,

Briefly, the method of obtaining data is as follows. After formulating the problem, an open-ended question* or, more rarely, a simple statement is worked out which contains certain key words or phrases related to the general problem. Wherever possible these key words are ones which have already been used by respondents in earlier studies or which are in current use to describe a program. Time limitations, unfortunately, seldom allow pre-testing. The question, together with instructions for interviewing and for obtaining information about the respondents, is sent to the various interviewers who then go about getting answers from members of their respective communities. Occasionally they are asked to interview specific groups, i.e., grocers, persons waiting in line to register for ration cards, but as a rule the selection is not so limited, and investigators are asked to reach as varied a group as possible. From time to time students of different age groups and of varied socio-economic backgrounds, men or women in clubs, women in nutrition courses, and so on are asked to write brief statements in answer to the same question. When specially skilled assistance is available, data based on related questions and other types of material can be obtained. Such information is often of great value as a check for interview material. As far as it is possible, all interviews are recorded verbatim, since only in this way can an accurate picture of verbal behavior be obtained. Interviewers also are instructed to note the replies of those who, for one reason or another, refuse to answer the interview question, since such replies may give valuable indications of negative reactions. Since the time limit for obtaining the data is invariably short, the replies may be considered to represent the trends of attitudes prevalent in the sections of the country sampled at *one* period.

In passing, it should be said that one of the great advantages of using

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* See Appendix A for the types of questions used during the past year.

student interviewers lies in the fact that the answers given them appear to be rather free of some of the biases and inhibitions exhibited in more "official" contacts. On one occasion when some interviewers inadvertently gave the impression of asking questions directly in behalf of the Government, the replies of the informants contained many phrases like, "You have to be careful what you say to the Government." The essays of school children, especially those by children of upper grade school and lower high school age, also have a particular advantage because of the ways in which they reflect current adult opinion, in vocabulary as well as in formulation. It should perhaps be added that such essays, as well as all other statements, are written without preparation or previous discussion of the subject at the time of writing.

When the data have been assembled, the preliminary analysis proceeds, community by community, or if it seems desirable, section by section within a community. For example, where the material from one community consists of essays by children of different ages, statements by members of a nutrition course, and a number of interviews, each group of replies will first be handled separately and then they will be integrated. To get a "feeling" of the community and to insure accuracy in the tabulation of vocabulary, it is important that all the material from one community be in the hands, or one might better say, in the mind of a single analyst.

In a general way, each reply may be studied as a whole to judge whether, for instance, the informant is in favor of, or critical of, or against whatever is under discussion. However, the real analysis centers about the breakdown of the reply into its component parts—into the responses. Each response is recorded separately. For instance, the following statement contains five responses; the total reply is in favor of enforced government rationing: "I think *enforced rationing is the only way* to do it *because everybody needs some meat* and *with voluntary rationing there are always some who cheat. This way the army gets what it needs* and *we can share the rest equally.*" A simple check-off system of recording is used; every time a response occurs it is checked off on the list. But where a single response recurs in the same sense in a single reply, it is only recorded once. This requires a certain amount of patience and attention to detail since it is important to note and to follow, as far as possible, the precise vocabulary—noting where alternate words are used with similar connotations—and, in addition, the relationship of one response to another within the whole statement. There is an obvious difference of pattern between two such statements as, ". . . . is getting short and so we should ration it," and, "We should ration . . . . to prevent a shortage." There is a more subtle but equally important difference between two such statements as, "My boys are in the Navy and so I am willing to do without so much . . . . ," and, "We should accept rationing of . . . . so that the boys in the Navy will have all they need." It is also important to prepare separate response lists for opposed types of answers. Thus, to anticipate a little, we will have in the end *Pattern A* which contains responses *a, b, c, d, e,* etc., and *Pattern B* which contains responses *m, n, o, p,* etc. There may be an overlapping of responses between two or more patterns; indeed, there usually is. Consequently, it is important that the lists be built up separately. The breakdown, however, is far less difficult than it would appear to be, because there are, in fact, *patterns of reaction* which manifest themselves in the use of certain types of expressions in similar sequences of recurrence.

The use of a simple check-off system of recording does not preclude a simultaneous breakdown into age or sex groups or any other for which data have been obtained, since this can be taken care of by such devices as the use of special marks, different colored pencils, etc. The type of attitude data does not, however, lend itself very well to mechanical tabulation.

When the preliminary analyses have been completed, the response lists from the various communities must be collated and drawn up into a total list. It is at this stage that differences in vocabulary or in emphasis in the various areas sampled should be noted, if they are significant. (This will already have been noted in some cases for sections of a single community.) Here again, in order that the range of attitudes and the relationships of the various elements to one another may be preserved, the tabulations must be worked out by a single analyst, preferably one who is entirely familiar with the replies as a whole, at least by having read through all of them. The material is now ready for the final steps of synthesis, diagrammatic representation, and interpretation.

In the course of the breakdown of total replies into responses it will have been observed that the number of responses in the individual replies varies rather widely. That is to say, the key words in the question have evoked a varied number of associations in the different respondents. It is not to be expected that any one answer will contain every response in a pattern, but rather that the pattern or patterns will emerge from a larger number of cases. Schematically presented this means that in *Pattern A:*

Reply	1	will contain responses	*a,*	*b,*	*c,*	*d*						
“	2	“ “ “		*b,*		*d,*	*e,*	*f*				
“	3	“ “ “		*b,*	*c*							
“	4	“ “ “		*b,*		*d,*		*f,*	*g,*	*h,*	*k*	
“	5	“ “ “		*b,*		*d,*	*e,*	*f,*		*h,*		and so on.

In *Pattern B:*

Reply	1	will contain responses	*m,*	*n,*	*o,*		*r*		
“	2	“ “ “		*n,*		*p,*		*d(A)*	
“	3	“ “ “	*m,*			*p,*		*d(A)*	
“	4	“ “ “		*n,*	*o,*		*r,*	*d(A)*	and so on.

Thus, it is clear that *Pattern A* is *a, b, c, d, e, f, g, h, k*. Or, since the emphasis on all points is not the same, *Pattern A,* correctly presented, is:

a, 5b, 2c, 4d, 2e, 3f, g, 2h, k

In the same way, *Pattern B* is:

2m, 3n, 2o, 2p, 2r, 3d(A)

One response, *d,* appears in both patterns. The possible significance of this will be discussed below.

Actually, of course, the total range of responses will be much greater than the purely schematic arrangement *a-k* in *Pattern A,* and the differences of emphasis will be much larger and more obvious; for example, there might be 50*b* and 30*f* but still only one *a* response. In relation to *b* and *f*, therefore, *a* would be an aberrant response and would be knocked out at this point, as far as the composite statement is concerned (but see below). Reducing the responses in this way until the core of greatest emphasis is reached the composite statement is arrived at. (The importance of a response made 10 times will necessarily depend on whether 100 or 1000 total replies are involved and a decision about what should be included must primarily be decided on this basis.) This might be presented schematically for *Pattern A:*

$$(5)b,\ (2)c,\ (4)d,\ (2)e,\ (3)f,\ (2)h$$

In building the composite statement, the arrangement of the responses is determined by their relationships to one another in the original replies.

From this composite statement a diagram can be built up, the primary purpose of which is to show graphically the interrelationship of the responses and the variations in stress. The schematic arrangement of the elements in the diagram is determined by their relationship in the composite statement. The proportions of the various parts of the diagram in relation to one another are fixed by the number of times a response has been made. The accompanying statement and diagram taken from *Beliefs about the Purpose of the Nutrition Program in Poughkeepsie, N. Y. Area* are given in illustration.*

The graphic representation of the results need not follow any rigid formula. Indeed, it cannot. Before building a diagram it is necessary to go back to the problem as it was formulated previous to the collection of data, in order that the results may be finally organized and interpreted. It will be recalled that the response material almost invariably falls into two or more patterns; two or more composite statements will then appear. All of these are, of course, interrelated. How the statements will be presented graphically depends to some extent on the original problem. That is to say, while the relationships of the elements within a pattern or the relationships between several patterns are controlled only by the material itself, there may be several ways in which these relationships can be expressed. It is here that problems of interpretation first arise. A few examples will serve to clarify this statement.

1. A similar response may appear in two opposed patterns (as d and $d(A)$ in *Patterns A* and *B* above)—for example, the statement, "Rationing is good because it *wakes people up to the war,*" as opposed to, "I don't like rationing. It is only done to *wake people up to the war.*" Here we have an overlapping of responses which should be highlighted in the presentation since, however logical within the context of each pattern, the argument is one which has already roused opposite reactions and therefore should be avoided as an appeal. This must be made clear to those who will make use of the results.

2. An integral part of a program, which it is necessary for people to understand if they are to cooperate fully in carrying out the program, may be

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* See Appendix B of this report.

mentioned by no more than three or four out of 500 respondents. Ordinarily, this response would be knocked out in making the synthesis (see *a* in *Pattern A* above). In this case, however, it is important, because of the problems involved, to see where it fits into the pattern and at the same time to show how it compares to other responses in importance. It should therefore be included in the graphic presentation.

3. The basic points of view expressed in two patterns may be so different that there is a special value in showing those points of contact that do exist and, more particularly, the areas of differentiation. This calls for a special form of presentation. Or,

4. The basic points of view about alternative programs, i.e., voluntary vs. enforced rationing, may be so similar that, once again, there may be a special value in overlaying, so to speak, the two patterns to show the basic similarities, especially the beliefs or values, that underlie both.

Each of these illustrations involves a special problem of presentation. Others might be added, but it is already apparent that in every case cited, the questions involved in the original problem as well as the results themselves affect the form of the diagram. Consequently, while the diagram is designed primarily to help those who are not familiar with the raw material to understand the results of the investigation, and while nothing can be shown in the diagram which is not inherent in the data, nevertheless its preparation involves a certain amount of preliminary interpretation. It is for this reason that the analyst must be entirely familiar with the data.

III

The larger problems of interpretation take one back to the original premise that language and action in a specific situation are linked forms of behavior. Both are moulded by the system of values, the beliefs, currently accepted. To discover what these beliefs are and where they are modified or even discarded over a period of time are major problems of interpretation, since a knowledge of values is essential to efficient long-term planning. Studies of verbal behavior are useful because, in expressing their opinions about a specific event, people most succinctly refer to the underlying premises on which opinion and action are based. Such studies also bring to light emotional conflicts which may lead to apparent contradictions between expressed ideas and actions.

For example, a respondent says, "I think rationing is a good idea because everyone gets his fair share; but there are always some people who cheat." One might expect the respondent to accept rationing with a good spirit on the basis of his answer; however, he has also expressed a fear which conflicts with his notion of equality. As long as this fear remains active, one may expect him to take measures to protect himself—to get what he considers to be his "fair share." The apparent contradiction between premise and (observed) behavior is dissolved by an understanding of the fear. Why the fear arises at this point and why it is turned against some member of the community ("rich" people, defense workers, and grocers were among those commonly accused in the early stages of rationing) are further problems of interpretation which a study of the total elements in the response patterns may resolve to some extent. A response of the kind described is important only for the individual if it is made by one person alone. Where such a response represents the attitude of many persons in many communities, it has great significance. Composite statements and diagrams bring to light the existence of such premises and contradictions on a large scale.

The study of several related sets of statements and diagrams shows how beliefs are affected by events; how older beliefs are called upon to make a new situation understandable; how such beliefs are modified and where new beliefs replace them. The studies we have made have suggested, for instance, the existence of a strong belief in competitive democracy. In addition to the argument that rationing is good because it gives everyone a fair share or because it prevents some people from getting more than their share, an occasional argument against rigid rationing has been, "Why should the army get more than we do?" More recent studies have suggested a modification of this belief in terms of need. Speaking of a growing shortage and of the method of distributing the food in question, some respondents have said, "Give it to those who need it most." Thus it is clear that a greater flexibility has been attained which can be made use of in the development of future programs. There also have been indications of an increased awareness of the need to include the allies in the sharing process. However, faced by an actual rationing program, the awareness tends to drop off for a time. This belief appears not to be very strong and consequently needs to be bolstered up by factual appeals, especially when personal deprivations must be faced. Other examples could be given.

As the war progresses, new situations of many kinds will arise and changes of vital concern to the people of the United States will continue to take place, probably on an ever increasing scale. It is to the interest of all that the course of action taken in each case be decided upon in a democratic manner so that the Government and the ordinary citizen may cooperate on a basis of mutual understanding. The use of the technique of analysis of verbal behavior described here is one means of providing a basis for the clarification of public attitudes.

APPENDIX A

Questions Used in Surveys

Why is the Government laying so much stress on nutrition?

What do you think about this business of registration?

To win the war it is important to include housing, transportation and food in the Government's war program. What do you think about this statement?

What do you think can be done about the meat shortage?

Which foods do you think are most important for us to have to keep up our morale? Why?

Which foods do you think are most important for us to have to keep up our spirits? Why?

What is your most important food problem today besides the cost of food? What do you think can be done about it?

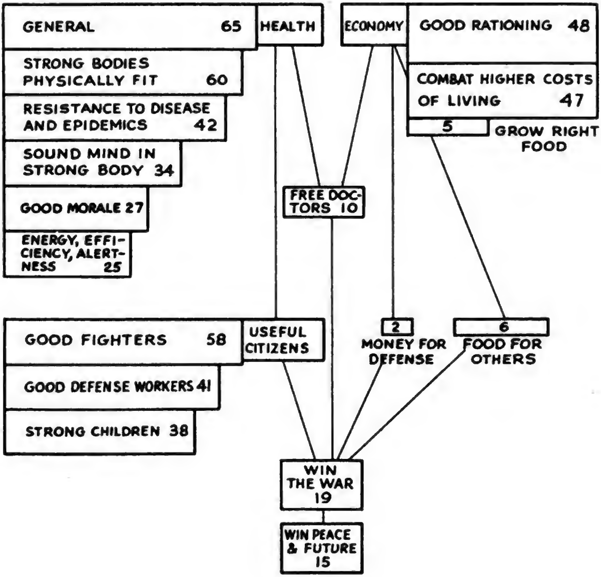
What do you think is the most important civilian food problem today besides the cost of food?

What do you think about rationing?

What kind of cheese do you like to eat? I understand there is going to be very little cheese available for civilian use next year. What do you think ought to be done about the small amount that is available then? Why? Why do you think cheese is important anyway?

APPENDIX B

Nutrition—Eat the Right Food



SUMMARY OF METHODS OF A FIELD WORK CLASS COOPERATING WITH THE COMMITTEE ON FOOD HABITS OF THE NATIONAL RESEARCH COUNCIL

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The work of a small group of seniors taking a course on "Methods of Field Work" in the department of Anthropology and Sociology at Queens College has been integrated in an interesting manner with the program of the Committee on Food Habits of the National Research Council. In the first semester of the Field Work Course, the various techniques and problems of field work are presented and training is given the students in choosing a problem, testing hypotheses, making schedules, sampling, techniques of interviewing, the writing up of interviews, and other related problems. The first practice is usually in making a small study on the campus, using students and staff as respondents. In the second semester the class does a field study in the larger community of Queens of which the students are residents. The course represents an attempt to correlate theory and practice in undergraduate work. It is of interest that seniors can do interesting and usable research while they are getting their training.

When the Committee on Food Habits of the National Research Council asked us to do a study on changes and problems of food habits caused by the war, it was easy to direct the work to this field. We had the advantage of having done a study the year before (1940-41) in a housing project of Queens where contacts had been made and a considerable amount of sociological data obtained, and it was decided to make the food study there. The project contained 3,000 families of a uniformly low income group, but of different ethnic and religious backgrounds. First, a number of preliminary planning conferences were held, attended by the instructor of nutrition classes at the Community Center of the Houses and representatives of the Community Center, the Council of Social Welfare, the Health Department of the Borough of Queens, the New York Housing Authority, the Committee on Food Habits, and Queens College. The Health Department formally sponsored the study and the work was done under their auspices. They were particularly interested in all our data related to nutrition problems. The services of the community were further enlisted through a Girl Scout troop which distributed food pamphlets for us.

In addition to the community cooperation and interest, the morale and interest of the students in the field work class were heightened because they were working on a problem related to the war and because they knew their research was being used. Indirectly, and in addition to the research training, the work was thus of some value in giving a group of students still on the campus some orientation and a role of helpfulness in the war effort.

Considerable time was spent in the classroom on the formulation of the problem and hypotheses. We had three control groups based on interest and exposure to nutrition data. Group One consisted of people attending nutrition classes; Group Two received a government pamphlet related to food and the war every two weeks; Group Three had no organized contact with food propaganda beyond what they got of their own accord through newspapers and radio. The first schedule was planned to determine the attitudes toward the relationship of food to winning the war, whether the people knew there was a relationship, and if so, what it was; their attitudes toward hoarding; and what, if any, changes they expected to make in their food habits. The second schedule was planned to find what actual changes in food habits were occurring. The behavior studied centered around the planning of meals, the preparation of food, use of white, dark, and enriched bread, and the use of irradiated and canned milk. The third schedule consisted of two parts, first, to determine the reaction and attitudes to the sugar rationing which had just taken place, and second, to recheck on the question in the first schedule concerning the general relationship of food and winning the war and the changes people expected to make. In all three schedules we were able to correlate our data with the nutritional knowledge and interest of the respondents. Each member of the sample was visited three times (and occasionally oftener) and we were thus able to get changes in a very dynamic situation as they were happening. The data from the interviews was discussed in class as it came in and new points of view and hypotheses were added to old ones. The problems of interviewing were also discussed in class as they occurred and likewise in conferences with individual students.

In addition to the study just indicated we were able also to meet several sudden requests from the Committee on Food Habits. One was for data on attitudes to soy products. A brief study was done (not in the housing project) on the degree to which people had used soy products, their association with them, and their willingness to use them. In this study we had a sample of 418 people taken at random. Another was to do a quick study on pre-testing two different phrasings of the question, "Which foods do you think are important for us to have (to keep up morale) (to keep our spirits up)?"

The study now in process (1943 Spring term) is a continuation of the study of attitudes toward rationing, this time, of course, toward a much more extensive rationing system. In addition, we attempt also to get at attitudes to sending food abroad to our allies and to occupied countries, and to obtain further data on reactions to and attitudes toward the nutrition classes held at the housing project. In this study we correlate attitudes to rationing and sending food abroad with the degree of participation in war effort, with ethnic background, and with age group.

Thus, during two years, two field work classes composed of senior undergraduate students have been able to make a study of attitudes and behavior related to food and the war in a rapidly changing situation and to catch some of the resulting changes in attitude as they were occurring. The plan of consistent interviewing over a period of time in the same setting (the housing project in this case) allows us to catch a dynamic war situation and to study attitudes in the process of change.

FOOD HABITS OF SELECTED SUBCULTURES IN THE UNITED STATES

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One aspect of the work of the Committee on Food Habits has been to issue a series of memoranda dealing with the food habits of several subcultural groups in the United States. These memoranda have been designed to give insight to and supply background material for aiding nutritionists, social service and community workers, who are concerned with food problems among their groups. The memoranda not only deal with the actual diet of the groups involved, but also present the social matrix in which food habits occur. Therefore they include living and working conditions, the family scene, the levels of education encountered, characteristic types of social organization, and the ways and means by which the diet might be improved.

Since the funds at the disposal of the Committee did not permit the recruiting of an extensive field staff, several methods have been devised which permit short cuts in the compilation of material, thus providing a substitute for door-to-door interviews. Of the five memoranda which have already been prepared, four follow what seems to be the most efficient technique in the prosecution of such research. This method involves the use of a volunteer collaborator of appropriate background who has had some training in the social sciences and who serves as both co-author and informant. Furthermore, such a collaborator has wide contacts among the group from which she comes, whereby she may obtain material on the questions that she cannot answer herself. This type of collaboration proves most fruitful, as discussions of the subject bring up points which only one worker studying the field might have overlooked.

Of course, these discussions have been supplemented by a thorough perusal of the printed literature available on the subject. Not only are works on food and appraisals of the diet consulted, but a wide variety of other publications are abstracted as well. These include orthodox sociological treatments of the groups studied, fictional material, church and fraternal annuals, magazines, and newspapers.

The third principal source of material comes from interviews with specialists familiar with the field. Out of their experience it is possible to obtain information very quickly. Some of the most valuable material has been obtained from physicians, social workers, school teachers, and newspaper editors. All of them have had wide contacts with the group that they serve, and are acutely sensitive to the critical points of both the food and social practices of the communities in which they work. When dealing with foreign language groups, consultation of these "experts" eliminates the problem of an interpreter essential to detailed interviewing. Furthermore, it is easier for a professional investigator to state his objective immediately and thus not spend time in building up the type of rapport needed to deal with lay people. It also does away with the necessity of translating questions into a lay vocabulary.

The general pattern of each of the memoranda has been built along the following lines: 1) the historical and cultural background of the group; 2) traditional methods of securing food; 3) habits of handling food, attitudes toward food, cooking, and service; 4) an appraisal of the customary diet; 5) how the diet may be altered and what means can be utilized to further this improvement. In one or two cases appendices have been added which give concrete illustrations of some specific attitudes toward food: proverbs, attitudes held about enriched bread, food stereotypes of the group. However, it is not possible to obtain the same type of information from each group studied because of the divergent beliefs and behaviors. For example, while the Italians, Poles, and Hungarians are amazingly verbal about their food habits and have elaborate series of proverbs and sayings on the subject, the Czechs and Norwegians appear to be totally devoid of food fantasy.

ITALIANS

The first memorandum to appear under the auspices of the Committee was "Some Italian Food Patterns and their Relationship to Wartime Problems of Food and Nutrition," issued in August 1942. This paper represented the joint efforts of Miss Genoeffa Nizzardini and the writer. Miss Nizzardini is a social worker who has had extensive experience in community work where many were from the Italian background group. This work and her own life enabled her to give much excellent information which was used in the study.

The tenacity with which the Italian clings to his traditional diet has become a byword among nutrition workers. Similarly he clings to many of the social patterns of the mother country.

Although there are many regional differences in language and culture in Italy which are duplicated here, it appears that it is common to most of the Italians to maintain some of the customary aspects of their diet despite unfavorable economic odds. Even if imported cheese and olive oil were expensive they would be bought, and if not available would be foregone. When there was no oil, they would cease to eat the raw vegetables so important to maintain dietary balance. With the outbreak of the war, they have had to find substitutes, Italian-type cheese and mixtures of oil. In this country they have taken to the use of white bread and have added sugar to their diet, both of which have thrown it out of balance.

The investigation of the social life of Italians reveals how these distortions might be combated. It would not suffice to prepare a nutrition text in Italian, because those Italians who do read, also read English. Many who have learned how to read are out of the habit and the radio might be a better means of reaching them. Any visual education program should stress two factors, that of color and that of the specific properties with which food is imbued. "Bread makes blood" is a well-known Italian saying and could very well be used to promote the enriched bread campaign, for the iron has been restored. The color factor is part of the aesthetic approach that Italians have toward food.

Italian family organization also may be important. The strict chaperonage of women is common and may interfere with attendance at a nutrition course. Furthermore, the approval and acceptance by the father of a practice might be necessary before the women would take it up. Many Italian men work in the food industries and know much about food, so that a program directed toward nutrition education in this group should be double-barrelled, aimed at both men and women.

Anxiety about food may become manifest in two ways. Although an Italian woman shops every day, she likes to have large quantities of staples on hand, which represent her margin of security. She may become anxious about the health of her children if they do not get what the doctor has ordered (a recent cultural development). There is great fear of tuberculosis among Italians, and a fat child is insurance against this ill.

There is a definite cycle of foods to be served throughout the week, and the diet balances over a week's time; fish on Fridays, "pasta" on Thursdays and Saturdays, meat on Sundays. Bread, meat and vegetables are bought each day from neighborhood stores and pushcarts, where the woman eyes each purchase and bargains. Their neighborhoods—most of them live in cities in the East—are large enough to support their own Italian stores where they can buy what they want. While other nationalities also support their own neighborhood institutions in cities and large towns, the population is distributed a little differently.

THE CENTRAL EUROPEANS

The Poles, Slovaks and Hungarians are found in large cities in the East and Middle West and in the smaller manufacturing and mining centers. The Czechs parallel this distribution, but extend further west and into the rural areas. The second memorandum published by the Committee on Food Habits is in three sections, and is entitled "Some Central European Food Patterns and Their Relationship to Wartime Problems of Food and Nutrition." Following the model set up for the Italian study, two of the sections are collaborative efforts. The first of these deals with the Poles and represents the joint endeavors of Miss Sula Benet, trained in anthropology at the University of Warsaw and Columbia University, and the writer. Miss Benet has done extensive field work among village communities in southern Poland and has worked on Polish newspapers in this country.

POLES

Although a varied food picture obtained in Poland, it was sufficiently homogeneous to set the keynote for a characteristic group of food habits prevalent among Poles in America. The basis for this was peasant life, centering on the self-sufficient farm. Grains (rye, wheat, buckwheat, and barley), potatoes, cabbages, legumes, and some green vegetables came from the patch of ground each family tilled. This was supplemented by milk, cheese, and sour cream from the family cow, a few eggs and fowl, some home-killed pork, or a little beef. Fruits, berries, wild mushrooms, dried for winter use, and fish, fresh from the lakes and rivers or salted from the Baltic, made up the balance. Salt, sugar, tea, and coffee, mostly used sparingly, were all that came from the outside. The prevailing Catholic religion and the eastern pattern of hospitality provided a pattern for the festivals and celebrations. The authority of the father was great, but each member of the family had his ordained task in its work.

The Poles came to America during a period of great industrial expansion and found a ready market for their labor in the mines and heavy industries. Although many of them wanted to settle on the land, either here or abroad, the lure of high wages was irresistible. Once in this country, like the Italians, they fell prey to the enchantments of white sugar and flour, and for much the same reason. Unlike the Italians, however, their family life was fraught with strains and tensions. Children left home, set out on their own, and became Americanized as rapidly as possible. With this Americanization came the abandonment of the rich vegetable soups, the bean soups, and the sour cream and cottage cheese dishes which made Polish diet so good. Many of the Polish girls are factory hands and as such presumably have enough command of English to enable them to read about nutrition. However, what they do read mostly are movie magazines and newspapers. To approach these girls, appeals should be made in terms of good looks and charm, because these are the most potent factors in the life of a young Polish woman. The more conservative married woman can be approached through the newspaper, because if she does not read this herself, her husband reads it aloud to her at night after work. There are many young men in the Polish background group who eat in restaurants and at work. They too need to be educated in proper eating and can be taught by posters at their place of work or at union meetings. Finally, the Poles are very well organized into nationality societies and all of them enjoy going to lectures, so that lectures on nutrition sponsored by these groups may be assured of a large attendance. Poles on farms can be reached through the facilities of state and federal agricultural aids.

HUNGARIANS

In background and in present living conditions, the Hungarians closely parallel the Poles. However, in Hungary, with the milder climate and the more fertile land, the diet of Hungarians was more varied and different in character. Where the Poles drank beer, the Hungarians drank wine, and their bread had more wheat flour. Many of the Hungarians ate a good deal of beef—and duck, goose, and chicken appeared on the table more often. Their folklore and proverbs were rich in statements expressing their attitude, one of great love of eating, toward food. Perhaps the most characteristic saying is "We may be poor but we live well." Once in this country, their four or five meals a day have been whittled down to three to fit in with the factory whistle. Like the Poles, they now prefer store-bought sweet buns for breakfast to the bread and smoked fat or cheese that, before they came to the United States, normally began their day, and which was followed with bread and cheese, or sausage or fruit, and coffee in the middle of the morning. The heavy noonday meal of stew or roasts has given way to a sandwich lunch eaten hastily on the premises or in a nearby restaurant, while their wonted supper of vegetables, eggs, sausage, and cheese has been displaced by a heavy cooked meal in which the raw vegetables no longer predominate. This régime allows no time off for a mid-afternoon snack. Like the Poles, the Hungarians are great joiners. They are in industries which are well unionized, and the suggestions for nutrition education among the Poles hold almost as well for the Hungarian groups. Not as many of their young women are in factories, and charm seems to have a less important appeal in this group, but they can be approached, as are young American girls, in terms of looks and health.

CZECHS

In sharp contrast to these two groups are the Czechs. The Czech section of the memorandum has been prepared by Svatava Pirkova-Jakobson, and the writer. Dr. Jakobson has a degree in sociology from the University of Prague and did work in many village communities, where she collected folk-songs. Her contacts with the Czechs in this country are many.

The Czechs are an exceedingly realistic people, largely Protestant, and they have a longer history of settlement in the United States than any of the other groups. Independent, progressive, and boasting one of the highest rates of literacy in the world, they came to America in large numbers in the middle nineteenth century. Some of them settled in the cities, while a large number went west and became farmers. Their traditional diet was rye bread, pork, goose (on holidays), sauerkraut, beans, pastry, and beer. On a Sunday a table in America will have the same dishes. In this country they are great coffee drinkers, and the coffee-pot stands on the stove the whole day long.

While Czech cooking is long and time-consuming, the Czech woman, even from the most conservative family, stays by her stove only because she wants to. If she cares to go out to work or to a meeting or to the library or to visit, she is free to do so. She is accorded as much freedom as she cares to take. Yet she cooks as did her mother before her and even her grandmother. In some districts in Nebraska, non-Czech women marrying Czechs will learn a whole new method of cooking, because the desire for Czech food is so strong. The family life is very warm, all members feeling that they have a stake in the home. On Sundays there is a great deal of visiting and huge quantities of food and beer are consumed. To refuse a second and a third helping of food is thoroughly impolite. The Czechs are the greatest joiners perhaps of any group in this country. They are members not only of their own groups, but of such completely American institutions as the Grange and the Red Cross. They are great readers; books, magazines and newspapers, in English and in Czech, find their way into all homes. Czechs can be approached for nutrition education via all the channels used to approach Americans.

The Moravians, who come from that part of the country immediately to the east of the Czechs, are rather like them, but the Slovaks, whose country is still further eastward, represent a group whose dietary patterns are intermediate between Czechs and Hungarians. Their lands are more fertile than those of the Czechs, and the climate milder. They are more strongly Catholic in their religious affiliations. In Slovakia they ate a great many more green vegetables than did the Czechs, and used more milk products. They are less literate than the Czechs, and they work in those same industries as do Poles and Hungarians.

All of these Central European peoples make wide use of whole grain foods such as bread or porridge; prepare liver, tongue, and other variety meats in many ways; are fond of sausage and, to a lesser extent, cheese. Dried mushrooms are well liked in soups. Many of these practices are still kept up in this country, but the diet has undergone some displacements.

THE AMERICAN NEGROES

The last of the major studies on food habits of minority groups is still in preparation. This treats with food patterns of American Negroes. For this study the collaboration of Mrs. Tomannie Thompson Walker, A.B., a student at the New York School of Social Work, was secured. Mrs. Walker majored in sociology at Queens College and, while still an undergraduate, worked on the Alpha Kappa Alpha nutrition project in Mississippi.

The fundamental premise of this study has been that there are no American Negro food habits. The rural Negro in the South eats substantially the same food as does his White neighbor of similar economic circumstance, while the Negro school teacher or physician reared in the North eats the same food which his White counterpart serves. At a bridge party or company dinner, similarly circumstanced Whites and Negroes will have the same party menu. Regional factors and economic conditions set the tone for food habits. In the rural South the well known traditional diet is meat, meal, and molasses, supplemented by greens and fish. In and around New Orleans, gumbo and shell-fish are local dishes, so here too the Negro eats them. In Virginia everybody drinks buttermilk, and he proves no exception. Slavery has left little impact on the diet of the Negro, but it did leave a tradition of women who worked. Among lower and lower middle class Negroes, especially in the cities, there are many women who go out to work, a factor which is bound to affect food habits. In these cities of the South the woman domestic worker does not eat at her place of employment, but tradition permits her to take leftovers home for her family. Since she has time off in the middle of the day, she may tend a garden patch which supplies her with greens. Southerners on farms shop once a week on Saturday, while in the cities they buy their food more often. In the large cities of the North, it is the usual practice to buy food every day. For a woman domestic worker in the North, it is usual to eat on the job and no allowance is made for leftovers to be reckoned as part of her wages. These circumstances of work have caused some individual local practices to arise, though they are by no means dissimilar to those which most people in this country adopt when faced with like situations. If a woman cannot get to the stores before or after work, she has to send someone else, her husband or her older children. If she cannot get supper for the children, then someone else must. If she has to be away from the house all day, the small children must be cared for and provision made for their meals. All of these are problems which are now facing many Americans for the first time, but to the working Negro mother they are an old story. To alter her food habits, the techniques used to approach White persons of like education, class level, and region should be used.

Many stereotypes about Negroes are held by White people and vice versa. One of the most typical is that all Negroes are born good cooks and that all of these good cooks never use a recipe or measure food. Actually, very few older cooks of any group ever learned to cook by recipe. Cooking was learned by observation and practice and recipe cooking is a phenomenon of rather recent age. Negroes too feel that they are better cooks than are White persons, and that White persons cook by recipe and not by "feel" or experience.

TESTS OF ACCEPTABILITY OF EMERGENCY RATIONS

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The treatment of food habits as but part of the total cultural complex has had further concrete application in some of the preparations now being made for feeding liberated countries. Since its inception, the Committee on Food Habits has been compiling material on the crucial points of the food habits of some nationalities. It was felt that while certain foods were not essential for the maintenance of life, they had definite morale value and made the acceptance of strange foods less traumatic. As the factor of familiarity is important in cushioning the impact of new foods, familiar seasonings and traditional methods of cooking go far to absorb such shock. A new food can be cooked in an old way and thus adopted with a minimum of friction. Adjustments in color and texture which may be made in manufacture or preparation go far in increasing acceptance.

A new aspect has been added by setting up tests of various concentrated foods which may be used in feeding liberated countries. Tests have been completed with two nationality groups—Greek and Norwegian—and the reactions and suggestions carefully noted and organized for the use of relief agencies. For these tests, again the advice and aid of a trained person of suitable nationality background was invoked.

Preliminary background material on the total picture was secured prior to the actual tests. Such factors as traditional diet, distinctions in food made by age, sex, and social condition, cooking and storage equipment and techniques, meal patterns, types of fuel available and used, resources for mass or individual feeding threw light on the problems which might arise.

In planning for emergency feeding, consideration of supply and nutrition determines the original plan.* Then acceptability tests make possible 1) minor alterations such as changes in color or texture and 2) the preparation of instructions in the foreign languages which will permit the standard ration to be adjusted to the traditional food habits of that area.

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* See minutes of the Liaison Session of the Committee on Food Habits on "Feeding Liberated Countries and Nutrition Education," January 23, 1943.

A SUMMARY OF A STUDY OF SOME PERSONALITY FACTORS IN BLOCK LEADERS IN LOW INCOME GROUPS*

This study was made in Detroit, with the assistance of graduate students in the School of Public Affairs and Social Work at Wayne University, and the cooperation of the Detroit Victory Aid Council. The material was analyzed by Mrs. Eva Shippee of the Committee on Food Habits.

The study was undertaken for the Committee on Food Habits to discover some of the personality factors which influence the success of the block leader, on whom the success of the nutrition program depends, and to evaluate some of the problems which confront her. Sixty-one block leaders were interviewed and classified, on the basis of the methods they used, into: 1) the "good" group, who distributed and explained the materials, enjoyed the interpersonal relationships of their work, and secured the maximum cooperation of their neighbors; 2) the "medium" group, who only distributed the material, and were discouraged by the obstacles, using them as excuses for not doing more; 3) the "poor" group, who had no personal contacts with their neighbors in their work but left the leaflets on door-steps or in mailboxes, or hired children to distribute them in this manner; 4) the "O" group, who had not participated in any campaign. It is especially significant that the difficulties are practically the same for each group, whereas attitudes vary from optimism and acceptance of the challenge, to complete discouragement and immediate seizure upon any difficulty as excuse for doing nothing further.

More of those in the "good" group than in any other volunteered for the work, had attended training meetings, were active in other organizations, enjoyed personal contacts with their neighbors, and had pleasant relationships with them. A positive relationship between self-confidence and an outgoing attitude was observed.

On the basis of these findings, the need for an effective administrative organization was stressed. It was recommended: 1) that duplication in assignment be avoided because of both its obvious inefficiency and its discouraging effect on the workers; 2) that publicity be given block leaders to insure their favorable reception; and 3) that not too much material be given the worker at one time.

If possible, only those who volunteer for the work should be used; the program and the activities should be carefully explained beforehand; the age of the volunteer's children, attitude toward work and people, motives for becoming a block leader, and personality traits should be considered; and an attempt made to use only women who fit into their neighborhoods from the point of view of social class and background. In the training, the need for personal contacts should be made clear, and expected difficulties and obstacles with recommendations for treatment should be discussed. The block leaders should know what their function is, understand its interpersonal character, and share experiences in the training group. Each campaign should be planned in advance to fit the particular needs of the community and here block leaders should be encouraged to contribute suggestions.

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* See "Publications of the Committee on Food Habits" on page 173 of this report.

PART III

RELATED RESEARCH

OUTLINE OF STUDIES ON FOOD HABITS IN RURAL SOUTHEAST

MARGARET T. CUSSLER and MARY L. DE GIVE

GENERAL CHARACTERIZATION

A series of three studies was carried on to ascertain the interrelations between the socio-cultural pattern and nutrition in three contrasting communities, field work in the summer of 1940 and during 1941-1942. The general method included intensive open-ended interviews cross checked by extensive interviews and survey of available technical data.

Bath, North Carolina

1. A sociological study of a Coastal Plain tobacco community involving analysis of factors like economy, food production, storage, distribution, health, and education in relation to nutritional adequacy of the community.

Results. Analysis of the diet and interpretation of interrelations incorporated in later general summary given below.

2. A follow-up study a year later to ascertain changes in food practices and attitudes toward food with particular reference to the National Nutrition Campaign.

Results. 1) Relatively few of the people were securing scientific nutritional information since radios, newspapers, magazines, and clubs were reaching only a third of the rural population. No government nutritional programs were affecting all the people in 1941. 2) There is still both a very serious milk deficiency and a dislike for milk and dairying. 3) Enriched flour was neither asked for by the rural people nor available in the local stores. 4) Longer tenure should be encouraged since it has a very important relation to canning, orchards, winter gardens, fencing, and equipment in the home. There was a deficiency in both canning and growth of winter gardens among all classes.

Available Reports:

1. Interrelations between the cultural pattern and nutrition. Extension Service Circular No. 366. Washington, D. C., United States Department of Agriculture, August 1941.
2. Let's look it in the eye. Consumers' Guide. Washington, D. C., United States Department of Agriculture, March 15, 1942.
3. Some cultural factors affecting the nutritional situation. Washington, D. C., Federal Security Agency, Nutrition Division, December 1941. (Unpublished.)

Dutch Fork, South Carolina

A reconnaissance study of a live-at-home community with a Swiss-German (Pennsylvania Dutch) cultural tradition.

Results. A brief study indicated some positive correlation between an integrated cultural pattern including characteristics of good farming, community pride, thrift, industriousness, stress on community schools, and the general standards of nutrition. It was also suggested that the very characteristics which comprised this particular cultural complex, and which manifested themselves in subsistence farms, were opposed to wartime expansion that would supply a food surplus.

Available Report:

1. Home-grown food and homely virtues. Washington, D. C., Federal Security Agency, Nutrition Division, February 1942. (Unpublished.)

Nuberg and Flat Rock, Georgia

1. A six-week test program to discover the relative effectiveness of various media in producing improvements in the county nutrition program and in diffusing nutritional information.

Results. A negative effectiveness of formal media for diffusing nutritional information was indicated except for definite short-range projects. Media used contacted mainly white owner, long-term sharecropper classes.

2. A study of the relation between the food pattern and 1) the social structure and 2) the local cultural values, using intensive interviews with selected informants.

The Food Pattern and the Social Structure

1. At present a cash crop (tobacco or cotton) economy seems to impede good nutrition in the South. Landlord-tenant relations affect nutrition for good or ill, depending upon their individual character.

2. All classes show variations in their level of diet, summer and winter, harvest and scarcity, weekday and Sunday, extra-routine and routine menus.

3. In general, White owners and long-term sharecroppers eat more food in greater variety than the White sharecroppers, Negro owners and sharecroppers, and White and Negro wage-laborers.

4. The authoritarian type of Southern family enhances the influence of the parents, particularly the mother, in the formation of food habits.

5. Racial differences in diet follow the pattern of class differences in that Whites generally eat more and in greater variety than Negroes, and owners of both races eat more than sharecroppers and wage-laborers. No intrinsic differential in diet due to race was discovered.

6. Neighborhood relations have significance for nutrition, both in patterning the lines of communication between residents through which nutrition information may diffuse and in patterning the distribution of the actual means of good nutrition, such as giving away of surpluses, lending of equipment, offering of services, etc. Decided preferences were found here.

7. Particular cultural concepts governing proper foods for persons in different circumstances of health, age, sex, etc., were found. Individual deviations from the food pattern which seemed to have no cultural patterning were also recorded.

8. Professional nutritionists in various agencies, both government and

educational, in a rural county, contact for the most part only the White owner and long-term sharecropper classes, but their influence in exchanging the traditional foodways for uniform national foodways is increasing. The relations with the doctor, the country storekeeper, and urban people are also becoming ever more influential in changing the regional foodways.

9. There are two main lines of communication operating in a rural Southeastern community: The horizontal class contacts, for example, between White owners and other White owners, and the plantation contacts in which the line of communication extends vertically among the landlord, tenants, sharecroppers and wagehands of a single establishment. Each type of communication is important for the diffusion of knowledge and techniques of good nutrition.

The Food Pattern and the Cultural Sanctions

1. There is a valid relation between cultural values and such a component aspect of the culture as the food pattern.

2. Four configurations were apparent in this Southeastern subculture:

Traditionalism, demonstrated in the foodways by the similarity of the older frontier dietary to the contemporary dietary, the disinclination to change methods of food production and preparation, and the failure of new cultural contacts to produce fundamental changes in food habits.

Rationalism, observable in the foodways in the introduction (especially among White owner, long-term sharecropper classes) of some progressive methods of food production, stress on purchased as opposed to home-raised foods, and the feeling that urban foodways are superior to rural foodways.

Affability, demonstrated in the foodways, in the catering to the food preferences of members of the family, minimizing the possible trauma of weaning, the sanction for strong emotional attitudes toward such foods as milk, meat, sweets, and (in this locality) English peas, the lack of a strict schedule for mealtimes, and a tolerant attitude toward between-meal eating.

Social distinctions, shown in the foodways by the sanction for the existence of food differences, for example, the attitude that the Negroes need less food than Whites, that certain foods are light and others heavy, that some have great prestige and others less prestige as the following lists indicate:

"LIGHT"	"HEAVY"
Liquids.	Meat (fat meat and lean meat).
Milk.	Beans.
Pot Liquor.	English Peas.
Hot Bread.	Cabbage.
Corn Bread.	Eggs.
Blackberry Wine.	Cake.
Butter.	
Grits.	
Oatmeal.	

HIGHLY ESTEEMED		LESS HIGHLY ESTEEMED
Home-raised	**Purchased**	
Chicken and Eggs.	Beef.	Dark Flour.
Corn Bread.	Steak Fish.	Yellow Corn Meal.
White Flour.	Ice Cream.	Black Molasses.
Vegetables.	Oranges.	Brown Sugar.
Peaches.	Celery.	Internal Organs of Animals except Brains.
Pecans.	Cauliflower.	Rabbit and Possum.
Honey.	Strawberries.	Poke Salat.
	Apples.	English Peas.
	Cheese.	Sweet Milk.
	Bananas.	
	Dates.	
	Pineapple.	
	Salmon.	
	Boiled Ham.	

3. Attitudes toward foods were found to comprise many non-rationalized components, that is, the reason for the value attached to chicken or hot bread did not seem to be apparent even to the informants themselves. In general, among the regional preferences may be seen particular regard for foods which are rare, store-bought, urban, packaged, canned, light colored, processed, refined, and changed in appearance.

Available Reports:

1. De Give, Mary L. Social interrelations and food habits in the rural southeast. Radcliffe College, 1943. Ph. D. thesis.
2. Cussler, Margaret T. Cultural sanctions of the food pattern in the rural southeast. Radcliffe College, 1943. Ph. D. thesis.
3. Cussler, Margaret T. and de Give, Mary L. The effect of human relations on food habits in the rural southeast. Applied Anthropology, 1: 13-18, 1942.
4. Cussler, Margaret T. and de Give, Mary L. Foods and nutrition in our rural southeast. Journal of Home Economics, 35: 280-282, 1943.

SOCIAL PROCESS AND DIETARY CHANGE *

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In an earlier paper describing the general results of the Southern Illinois Foodways Study,[2] it was explained that the purposes of the project were twofold: 1) to effect a preliminary isolation of certain general propositions concerning the integration of food habits with culture, and 2) to evolve a set of procedures for the modification of food habits in the particular rural area studied.† This combined theoretical and practical approach has led to an analytical focus upon the critical problem of dietary change as related to culture change. In this paper we propose to summarize our materials relating to this problem.

I

THEORETICAL CONSIDERATIONS

Since there are so many different foods used by any group of people, so many different dietary patterns and cooking practices in their cultural inventory, a simple catalogue would serve little purpose in an understanding of pattern. For example, while both beef and pork may be in use, there is a patent difference between the regular, universal use of pork meat, and the infrequent, episodic occurrence of beef in the diet. Such differences in the place of food in diet have led us to see a gradient of relative dietary importance in the food habits of the area. Those foods which are universal, regular, staple, important, and consistent in the form of use, we have, following Linton,[3] called the "core diet." When a food is widely used, but not universal (i.e., segmental), more variable in use and form, and less emotionally important, we use the term "secondary core." For while these foods are characteristically part of the diet, they do not have the fundamental, traditional force of the core foods. (They correspond to what Linton has called "specialties.") Finally, we have reserved the term "peripheral foods" for those which are least common, most infrequent in occurrence, and those which are not characteristic of groups, but rather of individuals. (This roughly corresponds to Linton's "alternatives.")

From a practical point of view, the distinctions seem of considerable value; for they enable us to state that greatest emotional resistance to dietary change is encountered in reference to the core items, less in the secondary core, and the greatest ease and fluidity of change in the peripheral zone.

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* Provision for the compilation of material relevant to the National Nutrition Campaign was made by the Committee on Food Habits.

† This paper will provide further exposition of some of the results of the Southern Illinois Foodways Study, a project sponsored by the Social Science Research Council and the University of Chicago.[1, 2] The present article represents an extreme condensation of a study to appear in the near future. For reasons of space limitation, it was found necessary to exclude consideration of the Negro area.

The terms are not absolute in their reference and depend to a large extent upon the unit that is being considered. Thus, if the entire area encompassed in the study is considered as a unit, the core diet—or the most common foods—tends to be less than the core diet characteristic of each subunit.* Similarly, when the segments (classes, status groups, etc.) of the subunits are considered, the core diet will tend to be larger than that of the subunit as a whole. Thus the core—or universal and staple common elements—is quantitatively less in an ascending scale from segment to subunit to area as a whole.

From a large historic view, it will be seen that one of the characteristics of culture change, with its attendant differentiation, is the reduction of the areal core in a quantitative sense, and the relative increase of the subunit and especially the segmental cores. That is, historically, the culture of food was more universal in the earlier periods, and progressively more differentiated as social changes alter the picture of a homogeneous area.

The general factors guiding acceptance or rejection of foods seems to be the degree of urbanization and the economic condition of the individual. If urbanization is high and economic condition favorable, foods of urban provenience are more readily acceptable. In the high urbanization, poor economic condition group, desire is present, but actual diet depends upon what can be manipulated within the straitened economic circumstances. Where urbanization is low and economic conditions favorable, the diet tends to be traditional, resistant to change, and fairly ample with new items as a secondary core or periphery. Finally, with low urbanization and poor economic conditions, the diet is resistant to change, meager, and virtually without innovation. Core elements may be dropped, but only because they cannot be produced or afforded. The level of aspiration is still the historic core.

II

THE HISTORIC DIET

The basic historical division was between Americans and Germans (also Negroes, who are not, however, considered in the present report).†

A. The Old American Diet

Food habits in the "old days" in the Old American areas were characteristically linked to the general regional folk pattern of mutual aid and collective action. Swapping and bartering of farm products was common; beef and pork "rings" operated, in which each farmer killed an animal and distributed the meat to the other members of the ring. The diet itself contained more of the staples that have long since been regarded as cash crop items: beef, corn and wheat flour. In the "old days," cattle, corn, and wheat were raised and consumed locally, the grains being ground by local mills which demanded a share of the flour as payment. Other foods that were important in this period but have since almost disappeared, were: fish, turkey, mutton, molasses, wild game, and wild greens. The latter two were exceptionally important in the bottoms, because that area was so fertile in flora and fauna.

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* The areas considered here are: Stringtown, the Bottoms, the Lower Hills, and the German Hills. The reader must be referred for details to the earlier report.[2]

† For materials on the Negroes, see 2.

The emphasis upon self-support was marked, and it took its form not only from the home use of crops and domesticated animals, but from a fuller utilization of environmental resources. In general, this pattern of self-support is perhaps the most prominent feature of this early period. In the words of an old resident, "We et ever' thing we could catch or kill except a turkey buzzard."

From extensive field materials, we can reconstruct the following basic dietary pattern for the early period:

Beef, mutton, pork.
Wild game: turkey, squirrel, rabbit, opossum, raccoon, deer, fish, turtle.
Vegetable: onions, carrots, peas (except green peas), beans of all kinds, okra, pumpkin, tomatoes, potatoes, cabbage, corn, cucumbers.
Chickens, ducks, geese.
Wheat and corn flour, locally produced (white bread and corn bread).
Milk and butter.
Sorghum molasses.
Fruits: blackberries, peaches, apples, melons.
Wild greens: poke, murdock of various kinds, mustard, dandelion.
Sugar, coffee, salt.
Preparations: certain old dishes, like beef stew, hog jowl with wild greens. Also pies, jams, jellies, etc.
General characteristics:

1. Less variety in the diet; consistent ways of preparing foods that rarely varied.
2. A more abundant diet, greater in quantity than the present.
3. Closer functional dependence upon environment; more hunting and collecting of natural foods.
4. Greater reliance upon home produced foods.

Within the historic diet can be distinguished several levels. First, we can segregate the "core," which contained, according to the values of the times, the most "necessary" foods for sustaining human life. These were: meat, particularly pork; potatoes; whole grain and corn bread; beans of all kinds; sorghum molasses; coffee; sugar; and salt.

Second, we find a secondary core, which includes everything except the elements listed in the core. This secondary core constituted a nutritionally important aspect of the diet, and was by no means slighted by the people of the period. In terms of cultural values, however, it was accessory to the staple core. In other words, any of the auxiliary foods would be given up before the staple articles. This is borne out by the descriptions of the diet during past periods of economic pressure: the bare minimum was usually the staple core plus whatever secondary foods could be hunted or grown.

Third, we can distinguish a preparation core, composed of a series of recipes and dishes, like stews, roasts, use of pork fat for cooking vegetables, extensive use of grease gravy, fruit preserves, and several others. The most consistent elements of the preparation core were those involving foods in the staple core.

B. The Old German Diet *

In the upland prairie and parkland of the Ozark spur lives a large block of population of German descent. In the area, the distinction between German and American is still retained and serves to indicate a major social differentiation. Coming over with a tradition of small-scale, intensive agriculture, the Germans settled in the area in large numbers from 1858 onwards. They brought with them such distinctive traits as two-story houses; cellars; large, well-built and well-tended barns; † and intensive farming plus a resolute ideal of household self-sufficiency.

By contrast with the Old American groups, German agriculture was more intense, diversified, and had greater variety in crops. While the soil was inferior to the richer flatlands and bottoms, it was free of the hazard of flood, and by care and devoted attention was kept up and even improved in the course of time. All around, however, erosion and soil exhaustion exacted their harsh tribute.

The Germans brought with them not only their language, agricultural practices, and ideals, but also their homeland food habits. The core of these was the same pork-beans-potatoes triad found among the Americans, but the characteristic preparations varied considerably. Concordance with environmental availability was extensive enough to enable them to carry over much of the traditional elements into the new situation.

The food habits that distinguished them from their neighbors may be summarized as follows: ‡

Greater use of heavy soups.
Preparation of various sausages: liver, pork, flour, head, frankfurters, bologna, salami, sausage balls, etc.
Boiled potatoes and potato salad.
Extensive use of rye—in bread, etc.
Use of barley.
Use of pickling preservative processes (with fruit acid and vinegar, salt, etc.) for meats and vegetables, rather than canning: thus, pickled cucumbers, tomatoes, turnips, kraut, etc.
Smoking of foods: smoked hams, smoked sausages, etc.
Preserved backbone and ribs.
Storage in subterranean cellars.
Head cheese.
Pickled pigs' feet.
Blood pudding.
Absence of cheese, except clabbered cheese.
Relative absence of sweet puddings and desserts.
Fruit orchards.
Wines from grape arbors.
Lesser use of grease in cooking.

The core food practices incorporated many of these and some newer elements that they learned from the Americans and found convenient in the new

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* The authors are indebted to their co-worker, Lt. Harvey L. Smith, U.S.A., for the field materials on the Germans. In the division of labor in the field, this was his specialty.

† It was often reported that the Germans built their barns before they built their houses.

‡ The present itemization and those that follow are, of course, not exhaustive. They would require too much space. These are given only as important and characteristic.

setting. By the time the community really took shape, the composite core, drawn from both German and American sources, was well entrenched. The historic core may be characterized as follows:

Ideal of self-sufficiency.
Basic use of hog meats in all forms.
Beans.
Sausage preparations (see above).
Head cheese.
Use of cellars for storage.
Boiled potatoes and potato salad.
Light bread.
Preserved backbone and ribs.
Cottage cheese.
Abundant fruit orchards.
Bacon and hamfat.
Intensive gardening.
Heavy soups: potato, barley, vegetable.
Barley.
Blood pudding.
Smoking of food.
Pickling preservative processes.
Corn bread.
Pickled pigs' feet.
Cereals.
Extensive use of dairy products.
Sorghum molasses.

In general, the historic core contains most of the traditional elements plus accretions of related American elements that were easily adoptable.

The secondary core is much smaller and contains elements that were employed by a large number of persons but were not universal:

Cheeses.
Fried chicken.
Kafekuchen.
Wines.
Pies and other desserts.
Hominy and other corn products.
Sugar.
Fried potatoes.
Use of beef and mutton products.
Rye bread.
Manufacture of beer.
Sweet potatoes.
Coffee.
Canning.
Use of wild game and plants.

In the peripheral zone, there was much variability and individuation and relative infrequence of occurrence. The elements of this sphere were imported from the American farmers and adventitiously brought in from the outside. They include:

Store foods of all kinds.
Biscuits and gravy for breakfast.
Cream gravies.
Salads—fruit and vegetable.
Rice.
Store flour.
Heavy use of grease.
Tropical fruits.
Exotics, such as oysters, cream pies, etc.

In the old days the core was very extensive. It included a large number of foods, processes, and practices, and it embraced virtually all of the community. The elements were in part of traditional derivation, in part adopted from the surrounding Americans, and showed a good environmental fit. While the secondary core was likewise extensive, the variation in usage corresponded to differences in social experience. Thus the older people clung with fervor to the old country traditions in the face of change and difficulties. The closer the families lived to the Old Americans, the greater was the approximation to their dietary styles. As we move to the heart of the German area, we find that the American practices tend to diminish except for those incorporated in the core diet. Also, store foods were resorted to by more urbanized folk, while the more rural retained the goal of self-sufficiency. The same considerations apply in more extreme form to the peripheral zone.

III

THE CONTEMPORARY DIET

A. Stringtown and the Lower Hills

The course of historic change in Stringtown has resulted from the twin impact of commercialization and urbanization.[4, 5] The gradual economic changes before World War I, which did not affect the basic economy, brought about the substitution of some store-purchased foods for home-produced items like flour, molasses, etc., plus a few novelties that were recommended by their convenience or taste. After the first World War, the basic economic structure changed in the direction of extreme dependence upon the outside and tenancy. The initial adjustment was to a moonshining economy which brought in money on a large scale and the virtual disappearance of gardening among the moonshiners. In this period, most food was purchased in stores, and urban food types and values became paramount. Most recently, with the abolition of moonshining, the community adjusted to a new type of existence.

The originally homogeneous farmer community became transformed into a segmented community where, while there is still considerable uniformity in foodways, significant differences of emphasis, aspiration, and actual diet can be found. We may describe these groups and their characteristic dietary patterns as briefly as possible.

A statistical analysis of foods consumed over a sample period of time yields the following breakdown of core, secondary, and peripheral elements for the entire community:

BREAKFAST

CORE	SECONDARY	PERIPHERAL	
Coffee.	Rolled oats.	Toast.	Prunes.
Meat (especially pork in various forms).	Eggs.	Syrup.	Chicken.
Gravy (milk and grease).	Milk.	Fruit.	Pancakes.
Biscuits.	White bread.	Potatoes.	
Butter.	Packaged cereals.	Kraut.	
Jelly.		Onions.	
		Cocoa.	

DINNER

CORE	SECONDARY	PERIPHERAL	
Meat (pork varieties).	Butter.	Biscuits.	Jelly.
Irish potatoes.	Corn bread.	Spaghetti.	Chicken soup.
Coffee.	Gravy.	Iced tea (summer).	Potato salad.
Beans (all varieties).	Apples.	Banana pudding.	Catsup.
White bread.	Cake.	Cheese.	Graham crackers.
Vegetables (in season).	Pickles.	Milk.	Fried pumpkin.
Sweet potatoes.	Fruit.	Chocolate milk.	
Pies.			

SUPPER

CORE	SECONDARY	PERIPHERAL	
White bread.	Beans.	Biscuits.	Chicken soup.
Butter.	Tomatoes.	Cake.	Pumpkin pie.
Irish potatoes.	Sweet potatoes.	Cookies.	Turnip greens.
Pork.	Pie.	Kraut.	Salmon.
Coffee.	Jelly.	Peas.	Lettuce.
	Sandwiches.	Pickles.	Sardines.
	Corn.	Graham crackers.	Eggs.
	Gravy.	Spaghetti.	Tomato juice.
	Milk.	Chocolate milk.	
	Fruit.	Cheese.	

Characteristics: Use of leftovers, extreme variability, relatively light meal, peripherality of vegetables.

When the distinct segments are considered, important variations of emphasis appear.

1. The well-to-do farmers. The general pattern for this group is very similar to the areal core, but all the items are more abundant. The majority of them are home-produced where economically possible, and minimal emphasis proportionately is placed upon store-purchase. Thus in the breakfast core, the meat is more likely to be from their own smokehouses than from the stores. While it is true that *proportionately* the store purchase is low, in absolute terms it is high. There is both more self-sufficiency and an ampler diet. Characteristically, they do a great deal of home canning and slaughtering of meat, and thus tend to have meat and home vegetables the year round. Most of the store purchases, aside from such staples as flour, salt, sugar, and coffee, are simply status indulgences or are used to fill in seasonal gaps.

2. Poor farmers and sharecroppers. In this group, the pattern is distorted by extreme paucity of all items. They are very dependent upon store purchase to fill seasonal gaps and the lack of ample gardens, chickens for home use, etc. The money purchase in this group is smaller than in group 1, but it is proportionately higher in their total food consumption. On the whole they aspire for ampler home-grown foods, like the wealthier farmers, but the desire for more store-purchased items is of greater importance.

3. Urbanized, casual labor, WPA and factory workers. In this sector is found virtually complete store dependence. The chief ambition is to eat like "city folks" and get away from the rural milieu. Dietary changes have been greatest here because of the absence of gardens and their dependence on money income. Variability is greater than for the other segments.

The Lower Hills subarea, while recognized as separate from Stringtown, exhibits a similar course of development. The primary difference lies in the fact that the Lower Hills is more "upper class." The majority of the upper group in the Lower Hills must be classified with Stringtown Group 1. The minority of approximately one-third must be classified with Stringtown Group 2. The same considerations as outlined above apply in these instances.

B. Dietary Change in the Bottoms

We will analyze changes in the Bottoms in terms of alterations in the historic core diet down to the present. During the earliest period, Bottoms culture and food habits were substantially identical with those of other American subareas.

At an early date, however, Bottoms land was divided into a number of large estates that were operated as a large-scale tenancy system. The former farm-owners were absorbed into the tenancy system, as were a large number of new families that moved into the area. The economic change occurred in the Bottoms earlier than in any other subarea, resulting in modifications that anticipated later types of "urbanization" elsewhere.

With the more concentrated effort required for raising cash crops, and the necessary use of all land—both a result of tenancy—there was less time to devote to gardening, hunting, and raising stock for home-consumption. The diet therefore began to change in the direction of more reliance upon the newly-introduced stores; molasses and flour, for example, began to be purchased. Other new urban foods began to appear: oranges and bananas were purchased as special treats; new varieties of spices; and the first processed foods.

As tenancy developed, the most important feature of culture change in regard to diet was the familial differentiation within the total group. No single family can be taken as representative of all, as could be done for the pre-tenancy period. It is necessary to distinguish subgroupings of families which correlate with dietary differences.

Between the early periods and the present, urban foods were continually entering the diet, and the old staple core became merged with some of the old secondary core foods to produce a traditional, "old-time farm-grub" concept. For our analysis of the contemporary period, we will call this new type of core, the "traditional core;" the new foods plus the older foods which are no longer in the core, the "secondary core," or the "peripheral diet," depending upon their type of integration within the diet.

The social system of the modern Bottoms consists of a series of rank-order positions based upon socio-economic status. At the top are the tenant farmers; below them the sharecroppers; * then a middle group: riverbank squatters, farm laborers, WPA workers; at the bottom, riverbank and shantyboat fishermen. Food has become attached to this status system [1] in that the tenant diet constitutes the dietary goal for all subordinate families, and that foods attached to the river people's (fishermen, primarily) diet have become of low-prestige.†

The Tenant Diet

Tenants are able to raise adequate gardens and have enough cash on hand to buy store foods both as luxuries or in the event of garden or stock failure. They have an essential *choice* in diet that is lacking in the lower status positions. The diet contains the largest proportion of both old foods and the newer alternatives.

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* Sharecroppers differ from tenants in size of land, or are in a relation of subtenancy with tenants.

† The shantyboat-dweller diet will not be discussed here for lack of space. It does show interesting divergencies from the land diet, as a result of diverse culture contact. As fisherman become riverbank squatters, their diet tends toward the agricultural type, however.

Traditional core. Contains basic triad of old staple core (beans, potatoes, pork). Also shows integration of old secondary foods, and preparation core items.

Secondary core. Consists of some old secondary foods that have failed to enter traditional core (turnips, chicken); some foods and variations of old staple core (corn bread, cracklings); and a group of urban foods that entered some time ago (cereals, canned vegetables).

Peripheral. Consists of a few foods from old secondary core; a number of "luxury" items (tinned meats, grapefruit); and very recent urbanisms.

Individual families vary from this ideal type in terms of their degree of mobility and contact they have had with other, usually urban, cultures.

The Sharecropper Diet

Although the sharecropper keenly aspires to the tenant diet, his diet actually differs from that type in the following ways:

1. Almost no variability around traditional core. These foods constitute major diet.
2. Secondary core foods are almost exclusively the old secondary core garden products—urban foods are relatively rare.
3. Peripheral foods rare, but when they do occur they are usually foods typical of the secondary core in the tenant diet—like canned vegetables. The whole picture is that of a diet held close to the traditional core because of economic limitation—the sharecropper lacks time and money for production and purchase of tenant-type diet.

The desire of sharecroppers (and other non-tenant people) to "eat like the tenants" means that the diet is held to a conservative level because they wish to achieve the traditional core goal; on the other hand, this desire promotes change in that the sharecropper also wishes to secure the newer urban foods associated with the tenant diet.

Riverbank-Farm Laborer Diet

This is an attenuation of the sharecropper type, expectable from the lower economic status, but it also contains some urban exotics, like oysters, cake, and wieners, that reflect the wishful thinking, urban aspirations of these highly mobile, acculturated people. A higher reliance upon cheap canned vegetables is also present. In general, the traditional core is penetrated by unbalanced secondary and peripheral items.

WPA Diet

It is in this diet that the most striking cultural changes are reflected. The departure from a farming economy is displayed in the formation of a totally new core diet: many of the older foods that can be grown in small gardens, plus a host of urbanisms like bologna, cookies, soft drinks, and the like. These are a direct result of the increased reliance upon a cash economy plus the influence of a cold-lunch pattern. Here the old staple core triad (beans, potatoes, pork) are all purchased.

C. The Contemporary German Diet

The passage of time has brought many changes in the German diet. Fundamentally, the changes may be attributed to the differentiating social processes which have acted upon the community. In summary form, these are three: commercialization, contact with Old American culture and partial acculturation to American culture modes, and urbanization. We may examine the consequences of these trends in terms of their effects upon food habits.

1. The commercialization of the area, which was relatively slow and reached its fullest development shortly after World War I, resulted in a greater reliance on cash crops, a corresponding lessening of household self-sufficiency, and increased familiarity with the ways of markets and towns.

The decline of self-sufficiency and the devotion of more energy to the production of cash crops vitally affected dietary custom. It was found necessary to supplement deficiencies in home-production by some store-purchase. While this process never went quite so far as it did in the other areas, it is nonetheless significant. It was necessary to buy food occasionally; and to buy food one had to have money. Thus the two processes supported one another.

Store-purchased foods, which had formerly been in the periphery, began to appear in the core. Flour, cornmeal, canned fruits, and vegetables all became more important. Also it became easier to purchase sausages and other foods that took too much time in arduous preparation.

Grumble though the old-timers might, the core was subtly changed to include packaged cereals, macaroni, and some canned goods.

2. As the Germans came to share more of the way of life of their American neighbors, many of the older foods began to be replaced by items that were more convenient. Housewives became more familiar with new foods and modes of preparation and adopted suitable ones from among those they came in contact with—such as canning. Gradually they dropped those taking much time. The latter began to drop from the core and enter the secondary core.*

Many persons also began to respond to the evaluations and taboos of their neighbors and attempted to conform. Thus, several German foods were regarded with extreme distaste by the Americans, and they began to drop to the periphery. They became symbols of a different status group, and from the point of view of the Americans, a lower status. Blood puddings are one of the most important items. Through the response to negative evaluation, many Germans eliminated such items or else used them rarely. In general, the patterning of responses to these low-prestige foods was similar to those found in the Bottoms in connection with the river-people's diet.

Finally, it is found that the younger people have an increasingly common world of understandings, goals, and ambitions with their age-mates of Old American descent. This situation is reflected in their lack of taste for the old German foods.

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* It may be pointed out that the diffusion was not all in one direction; a few German items made their way into the American diet.

3. The protean impact of urbanism has further altered the historic core in the direction of conformity with the surrounding area. German families have developed considerable contact with relatives and friends in nearby towns, including intermarriage. From these they acquire new food habits and standards.

The trend toward secondary school education for the girls has taken future homemakers outside the community, where they acquire new foodways. The press and radio, playing upon receptive social areas, have had their effects.

Three groupings result from these processes:

1. The traditional group, which consists of older persons and others who value the past, is the most self-sufficient in the area. Most of the historic core is retained, with the addition of a few store-purchases plus certain easily adaptable American foodways, such as a greater variety of pork preparations. Canning, which promotes self-sufficiency, is prevalent.

2. In the group relatively acculturated to American standards, the core is similar to the American core, particularly the "upper-class" Americans. Most traditional foods have been dropped, especially those with low-prestige, like blood pudding and head cheese. This group still lives "out of the farm," rather than "out of the store," exceeding in this respect most of the American groups, save possibly the Lower Hills people with whom they associate.

3. A small constant core is found in the most highly urbanized group, for here the disposition to accept outside foods is limited only by individual taste, finances, and knowledge of foods. The garden is less important; home production is drastically reduced. Store purchase increases, and the diet, with its "delicacies," etc., more nearly approaches urban standards. Change is rapid.

IV

SUMMARY

The historic and contemporary diets of the area of Stringtown, Illinois, were analyzed in terms of the concept of core, secondary core, and alternative. The changes were seen to result from commercialization, urbanization, and contact between groups (Germans and Old Americans). As a consequence of the social change, in the present we find differing segments instead of a fairly homogeneous farmer population. Differences in food habits, as well as differences in resistivity to change in food habits were seen to be closely related to the contemporary social structure.

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PART IV

SUMMARIES OF COMMITTEE CONFERENCES

RESEARCH IN THE FIELD OF FOOD HABITS*

MAY 23-24, 1941

Reports on significant developments in food habits throughout the country with special emphasis on the South and Southeast.

Dr. I. H. Moore (Director Child Health Demonstration, Sparta, Ga.): I am Health Officer Hancock County: strictly rural county; population 12,764 (10,000 Negro); 15% employed in lumber industry; 10% live in Sparta; remainder farmers—75% tenants with about 35% on share crop basis. Child Health Demonstration begun July 1936. To improve economic, social, and health standards, worked out 1) plans and objectives, 2) minimum general public health program, 3) special emphasis on Child Health and applied nutrition.

Typical meals of tenant farmers: *breakfast*—corn pone, fried pork, syrup on biscuits, flour gravy; *dinner*—fried dinner same as breakfast; boiled dinner, one vegetable long cooked with fatback, corn bread, syrup; *supper*—leftovers from dinner. Few fruits; poor milk, if any. Post partum diet of mother—rice, grits, light bread and butter, coffee. Vegetables, fresh meat, eggs, fish, and milk were thought dangerous. Geophagy widespread. Cash income $250.00, kind $350.00 per annum. Objectives of program: to teach fundamentals of good nutritional practices within economic means. Techniques: garden project under care of expert gardener for 16 families; canning service; cooking and menu planning service; nutrition education-moving pictures, posters, newspaper articles, form letters, public talks and lectures, nutrition literature, personal conferences, nutrition classes held in prenatal and well-baby clinics; school lunch project—expected to expand so every school in county will serve adequate lunch for nominal cost, produce or work, school garden.

Cooperating Agencies: U. S. Children's Bureau, University System of Georgia, Agricultural Extension Service; county agents, Home Demonstration agents, Vocational Agriculture teachers; Georgia Experiment Station; WPA and NYA.

Results: 1) Significant health improvement, especially of infants and school children. 2) Food habits definitely improved—prenatal diets show distinct improvement in use of milk, eggs, and vegetables but not in kind or amount of meat from 1936-41. During 1942-43 fatback meat food habit easily changed by food demonstrations in meat cookery. 3) Program based upon 7 years experience which should produce rapid and significant improvement in nutritional status of rural communities outlined.

Conclusions: 1) There is great and urgent need for widespread use of similar programs in the rural Southeast. 2) The success of such programs depends fundamentally upon the effectiveness of educational techniques used to convey scientific knowledge to average citizen. 3) Rapidity of improvement in nutritional status of rural population group is largely dependent upon coordination of effort and unity of purpose of local personnel of all community betterment agencies.

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* See minutes of the conference of Committee on Food Habits, May 23-24, 1941, under same title.

Dr. Harold F. Clark (Teacher's College, Columbia University): An Experiment in Applied Economics; financed by Sloan Foundation. One experiment in Southern Appalachian Mountains. Measure food available, teach community how to improve conditions, measure again. Attempt to discover whether education without economic change can change diet. Worked through schools. Found farmers in bottom third of group could not read experiment station bulletins. Adapted material for use in second grade of school. Problem of food storage of vast importance.

Dr. Muriel W. Brown (United States Office of Education): Experiment in Obion County, Tenn. Population about 30,000 (10,000 in county seat); wide variety in living conditions. People on committees felt need for nutrition education, but people themselves did not know they had problems. Decided to slant education so people would find out for themselves. Worked through schools, interested agencies, and lay committees working in each small population center. *Plan:* reach families through conferences in schools and nutritional clinics in each center; follow up in community through clinic; integrated program of nutritional education, all through schools. Teachers visited homes informally to get cooperation; children brought parents to clinics; older children helped in clinics. Teachers discovered own need for nutrition education; need for clinics felt in communities. Council of county agencies formed to coordinate services to needy families—Red Cross in charge of emergency programs. Garden project, hot lunch program, increased use of whole grain cereals, summer study project for teachers, youth council (high school students) write history and keep records. Tried not to let teachers diagnose children. Malnutrition not found definitely related to economic status. Lack of mobility made check of foods relatively easy in community; used local people to check amount of food in houses from time to time.

Dr. Clark: Important changes are in process. Storage and preservation definitely improved. Expected changes to be much slower than they are. Why so rapid?

Dr. Ruth Benedict: Prestige groups could be used to effect changes.

Dr. Clark: We are looking for a technique that will work anywhere rather than trying to improve community. Have stayed away from minority groups because of difficulty of transfer. Changes can be made in almost any economic situation; if you can teach children, they will teach parents. New books prepared were taken out of schools and read in homes though previously textbooks never were taken out.

Dr. T. J. Woofter: Obion County preparation of food in schools—crucial point to transfer between generations. New diet must be liked, to stick.

Dr. Moore: Do not yet have techniques for measuring spread from prestige groups.

Dr. Clark: Almost universally, bottom third not touched by county agents.

Dr. Charles Johnson: Shows need for change of method. Know people cannot change even when they have information—due to prestige value of certain foods, also health beliefs.

Dr. Rensis Likert: There is need for more data on values placed on foods within the community. Must also get data on knowledge and attitudes to see what causes changes.

Dr. Johnson: Might get better results with trained Negro investigators. Standard English textbooks may be too difficult for lower third; better write idiomatically. Hot lunch program another way of reaching group.

Dr. Brown: Especially when the program is a cooperative one—parents and children.

Dr. Russell Wilder: Some difficulties may be due to diet deficiencies.

Dr. Dorothy Dickins: Necessary to teach people that new ways are not temporary, but here to stay. Must look for reasons for geophagy, etc.—meet biological needs.

Dr. Likert: Since we cannot teach perfect diet, what is first step that should be taken? Need to know ways in which patterns can be corrected within economic limits.

Dr. Wilder: Main problem is knowing what are minimum standards of food and nutrition; coupled with that, the level to which that standard is now set. Possible danger in setting standard higher than people can reach.

Dr. Hazel K. Stiebeling: Have set up three satisfactory but less than ideal diets, one emergency diet. One-fourth of people in United States could not afford even cheaper forms of adequate diet. Standards excellent, but practically unattainable for most of lower third.

Dr. Wilder: Best we can offer is a kind of yardstick by which diet can be measured—get as near to as possible. Harder to determine minimums than satisfactory diet. People in France manage to stay more or less alive—depending on what is meant by alive. Should not set up standard as something everyone *must* achieve—but rather as something to work toward. Therefore should put the goal as high as we can and explain meaning.

Dr. H. D. Kruse (Milbank Memorial Fund): Exact number of people malnourished not known. Past methods for detection discredited and abandoned. Evidence shows that much unsatisfactory nutrition in population is in latent or subclinical state. Some new methods for detection evolved. United States Public Health Service, Department of Preventive Medicine and Pediatrics of Cornell University Medical College, New York City Department of Health, and Milbank Memorial Fund joined in setting up a project to apply and evaluate a series of these methods. Worked with 2150 boys and girls in public high schools, 350 pupils in private high school, 130 WPA people. Can now report (after 2½ years) on prevalence of three deficiencies— iron, ascorbic acid, and riboflavin. Of high income group, 1% had low hemoglobin values, 6% had low plasma ascorbic acid levels, 2% showed definite signs of ariboflavinosis. Of low income group, 4% had low hemoglobin values, 47% had unsatisfactory plasma ascorbic acid concentrations, 75% (of 512) showed signs of ariboflavinosis. Among WPA personnel, 13% had low hemoglobin values, 61% had low plasma ascorbic acid levels, 35% showed ocular manifestations of ariboflavinosis—less prevalent but more severe than among low income group children. Indicates statements based on dietary surveys have not overstated actual nutritional conditions. Tests ought to be used more widely—only way to assess malnutrition problem and make plans for correction. Difficult to recognize deficiencies in people without examinations. Gave WPA people therapeutic treatment. Later gave dietary advice. But generally desirable to improve diet as soon as possible.

Dr. Moore: Must find malnourished; but also must make population really want proper diet.

Dr. Benedict: Important question is *how*—not *why*. Must find out how one thing is correlated to other factors and how changes can be made.

Dr. Vilhjalmur Stefansson: Grew up on frontier, lived partly by hunting. On exploration trips often lived exclusively on animal tissue several months at a time, the various periods adding up to about five years. Dieticians were sceptical and expected bad results if reports were true. Examinations by a number of doctors (results published in J. Amer. Med. Assoc.) showed none of expected bad results. American Meat Institute wished to reprint articles; permission refused. Suggested that instead an experiment be carried out for one year at Russell Sage Institute. Together with colleague agreed to live for year, 1928-29, on an exclusively carnivorous diet. During first several weeks all meat weighed in advance; thereafter ate as pleased. During first months meat fried, roasted, or boiled; thereafter usually boiled, medium, or well done. During experiment never ate whole animal and always had meat cooked, not raw. Results have been published by Dr. Eugene F. Du Bois and other supervising scientists in various technical journals; popular account by Stefansson in Harper's Magazine. Ten years later persuaded American Meat Institute to found three dietetic fellowships, one for study of anthropoid diet by Lasker under Hooton at Harvard, two for studies of hunting peoples at Columbia by Joffe and Posnanski under Benedict, Linton, and Strong. Research being continued in own library.

Dr. Benedict: Fellowships were surveys of literature. Many problems arising must be studied in field. Problem of clay eating. Some tribes always eat. Some say prelude to insanity—and it is; some say will kill pregnant women—and they die at childbirth. Question whether a matter of mental states or chemical effect.

Mr. Meredith C. Wilson (Extension Service, Dept. of Agriculture): Function of extension education to teach those who have desire for information and to create desire for information on part of those who do not have it. Too often neglect second part. Possible to influence 96-97% of farmers; usually touch about 75%. Two studies bearing on food habits; measurement of growth in knowledge resulting from 4-5 months' participation in 4-H Club work—showed where changes needed; survey of home food production and consumption habits of farm families in two Ohio counties—sample areas represented good and bad land; about ⅓ tenant families with cash expenditure per year under $400. Study showed 46% adults, 61% children consumed 3 or more cups milk daily; 8% adults, 2% children no milk; practically all families used butter; 41% adults, 43% children ate raw fruit or vitamin rich food 5-7 days a week; additional 40% adults, 34% children ate same 3-4 days a week; 34% adults, 37% children ate one green or yellow vegetable daily; 50% adults, 53% children ate one or more servings whole grain or lightly milled cereal or bread, or bread made from enriched flour daily; 97% families canned home produced fruit and/or vegetables—average 176 quarts per family. Green, leafy or yellow vegetables grown by 98% families. (Three-fourths of the families reported that all family members disliked an average of four different kinds of green, leafy, and yellow vegetables. In 25 to 40% of the homes, all members of the family disliked turnip greens, mustard greens, kale, Swiss chard, asparagus, spinach, and broccoli. In 10 to 25% of the families, all members disliked winter squash, wild greens, peppers, and carrots.)

Miss Gladys Gallup (Extension Service): Significant part of study was actually getting into homes. But need to perfect ways of evaluating success of projects and teaching methods.

Mr. Wilson: Portion of funds for experimental project ought to be earmarked for use in evaluation.

Dr. Ethel Waring (Cornell University): Can new food habits be learned? Can old food habits be changed? Yes, at pre-school age—under guidance of parents as well as of specialists. Based on studies New York State College of Home Economics, Cornell U. Studies of the learning of 10 best and 10 poorest eaters, judged by measures taken first month in nursery school for 66 children (Genetic Psych. Monogr.). Intensive individual studies by means of motion picture film and stenographic record; analyzed—established techniques of observing, recording, analyzing. Basis for investigating was question: What does the adult do to get the child to take over for himself the new goals the adult has for him? Adult practices classified according to outcome; generalizations made in form of working principles—stated in terms meaningful to parents. Three adult relationships of adult to child in changing food habits possible: neutral, opposed, cooperative (see Cornell U. Bull. 420, *Working Principles in Child Guidance*). One film demonstrates how mother can change guidance by getting cooperative relation. Question: Do same relationships prevail among adults, so home visiting teacher or worker can get family or family member to take over new goals? Study made in rural community with special emphasis on techniques whereby rapport was developed which established cooperative relationship (submitted for bulletin, E. J. Freeman: *Family Education through Home Visiting*). Cornell studies show new food habits can be learned and old ones changed with minimum of strain and evidence of pleasure in acquired learnings. Depends on skillful guidance based on general principles, not on specific practices.

Mr. Ernest E. Maes (Office of Indian Affairs, Dept. of Interior): Inter-American Indian Institute organized as result of first Inter-American Conference on Indian Life. Dr. M. L. Wilson member of policy-making committee for part of project. One field representative to go to Central America, another to South America. I am going to South America to see what is being done for Indian populations. Diet information part of survey. Expect to find people interested in improvement of health habits of Indian population, who will want to know what is being done here. Would like suggestions for making surveys of food habits in each country.

Dr. Benedict: Tied up with land problems—whether Indians have retained land or not. Detailed studies of food intake depend upon knowledge of how much land is available. Great contrast in this item; difficult to get any idea. Can tell whether people eat enough, but not what governments can do, without detailed study of land ownership and availability.

Miss Genoeffa Nizzardini (Formerly, Advisory Commission to the Council on National Defense): 1930 Census showed United States population 122,775,046, of which 4,546,877 (3.703%) Italian stock—1,790,425 (37%) born in Italy, 2,756,453 (63%) native born American with one or both parents Italian born. Live in every state including District of Columbia, percentage of Italian stock to total state population varies from less than .5%, .143% in Oklahoma, to 14.1% in Connecticut. Six eastern states (New York, New Jersey, Pennsylvania, Rhode Island, Connecticut, Massachusetts) have 72.9% of entire Italian stock. In 92 cities Italian population 5,000 or more; percentage of Italians to total population of cities varies from 2.035% (Seattle, Wash.) to 59.7% (Lodi, N. J.), 40.8% (Milford, Pa.), 33.8% (Port Chester, N. Y.). Three cities with largest number Italians are: New York City (1,070,355), Philadelphia (182,368) and Chicago (181,861).

Diet one phase of Italian culture which has yielded least to outside pressure. "Little Italys" support own green grocers, bakeries (decade ago served primarily as community ovens), latticini (soft cheeses and handmade macaroni), Italian-American grocery stores (do not patronize chain stores), pizzerias. Because so many items of diet supplied within group, diet plays important rôle in contacts with outside groups: hospitals, convalescent care, fresh air care for children, school lunch program, "Y" suppers, CCC boys, Army diet. Diet has definite characteristics. Need to know how people combine foods, what characteristic tastes are preferred in order to suggest modifications. No existing study of Italian diet. Families receiving aid not in position to explain preferences. No Italian background nutritionists. Position of Italians as minority group has made them protective about customs and habits. Need analysis of the diet pattern in operation in the kitchens of millions of American housewives of Italian descent. What forces have played on group, causing what changes? Are changes consistent with dietary standards we want to achieve?

Study of second generation girl would give information on childhood and neighbors, on swapping of recipes from different sections of Italy. Girl should be elementary school graduate because then would have had lessons in American cooking. Study would give picture of kind and extent of changes. Directions of changes could be evaluated in light of present-day dietetic standards. Could work out acceptable methods for bringing diet habits closer to accepted dietetic practice. Preserve good features and blend in additions. Would give local groups all over country working with Italians essential information. Preliminary study suggests need for study of cooking methods—capitalize on preferences. Definition of portions—in Italian meals portions are actually courses. Development of vocabulary regarding dietary and related areas—English names of foods, cooking terms, table service, etc. Should evaluate changes beginning to operate and then hasten some and stop others, such as reluctance to admit using "peasant" dishes, substitution of soft bread for hard, crusty bread, adoption of sweet desserts, adoption of blanched celery, etc.

Dr. M. L. Wilson: (Extension Service, United States Dept. of Agriculture): Object to get reports of research and work having to do with food habits. Research falls into two categories: 1) biological and physiochemical and 2) psychological and cultural. Must find how much failure of people to meet standards due to economic causes, how much due to culture and habit patterns. Calls for closer cooperation of sciences. Social sciences must try to catch up to biological sciences.

Dr. Richard Osborn Cummings (Formerly, Division of Statistical and Historical Research, Bureau of Agricultural Economics, United States Dept. of Agriculture): Historically much evidence to substantiate changes in food habits. Studies show loss of appreciation of certain foods (acorns in Europe) and survival of prejudices regarding others (fresh fruits and vegetables associated with fevers, malaria, etc.). Why—how—losses in appreciation of diets take place are fundamental considerations in discussion of social aspects of nutrition. Must take into consideration variety of individual, environmental, and social factors. Must consider heredity, differences and changes of taste with age, natural environment. For example, differences of soil and correlations with nutritional deficiencies—thyroid deficiencies and use of iodized salt in Michigan. Changes in ways of living occasioned by reforms and technology important—17th century interest in rickets in England—may be identified with enclosure movement. Miserable living conditions due to industrial revolution—see Charles Dickens' works. Effect of modern methods of food processing. Must study diets at different economic levels. War may effect changes in any one or all levels—England at present time. But must take into account existing prejudices (Englishman's dislike of goat meat, horse meat, etc.). Must also consider racial, religious, and moral prejudices (game birds and work of Audubon Society). Must consider factor of education—are concerned not only with what child eats, but how he eats it. Pleasure. Children in cafeterias in Hawaii. Pleasure used in advertising (Castoria, "Force" campaign). Importance of psychological factors and symbols attached to food should be investigated further—association of blood with tomatoes made boy in Polish village like them, orthodox Jews dislike them; association of color of bread with social status—one reason for eating white breads. Earliest American survey of food habits recorded was state survey made in 1870's concentrating primarily on rural population. First really scientific surveys made by Atwater in Massachusetts in late 1880's. Came to Washington to work with Bureau of Labor. Earliest surveys with aid of agricultural stations started in 1890's; available in experiment station reports. Whole series made in different parts of country; diets of Negroes, lumbermen, college men, etc., separately treated.

Dr. Douglas Oliver (Formerly, Brooklyn College, Brooklyn, N. Y.*): Will make a community study of a small Iowa town to learn something about agricultural economics. Led to undertake study because of experience of previous field study of the Siuai culture and neighboring cultures in southern Bougainville. Began with study of totemism, clan history, etc., but found little local interest in these. Study of leadership showed that leader was a successful social climber who gained political status through prestige won by control of food resources. Based on accumulation and distribution of large quantities of vegetables and pigs. Man who gave largest feast won most prestige. Leadership had nothing to do with inherited status; was matter of controlling production, exchange, and consumption of food. Led to study of techniques of production and effect of exchange upon social interactions. Comparative data from closely related neighboring culture showed far-reaching effects of slight changes in food habits. In neighboring culture no interest in pig raising; main crop taro which cannot be conspicuously consumed at lavish feasts. Here descent matrilineal, residence matrilocal—no emphasis upon social climbing and leadership. Whereas in Siuai pork was important food, pig raising a vital enterprise. Pigs, in hands of men traders, formed capital goods—used to accumulate wealth and prestige. From this developed male-dominated political institutions; residence became patrilocal; change over from matrilineal to patrilineal descent in progress. All made possible by different food habits. Study of land tenure also led back to consideration of food habits; land tenure principles derived from patterns of utilization and farming techniques—ultimately depended upon diet standards. When writing up data looked for usefully comparative material—works of Richards, Malinowski, Firth, and Forde helpful but not detailed enough. Turned to agricultural economics—found raw material but not in sociological framework. Came across some points suggestive of institutions found in Melanesian communities and so decided to undertake study of an American rural community. Got financial support of Social Science Research Council and in September will begin study. Chose Iowa because more chance of finding a community not a cultural island and not complicated by racial antagonisms and extreme poverty. Some basic problems are 1) what effect type of production has upon interaction of people, and how that results in social stratification and leadership; 2) how men climb the agricultural ladder and become leaders; 3) what effects the production techniques have upon land utilization and tenure. Later hope to reconstruct local history, see effect of introduction of new techniques of food production on social stratification, leadership, and land tenure. Intend to keep food habits central to investigation. Hope to explore possibilities of working with agricultural administrators—find out what they know and want to know, how to present results to them. Will work parallel with officials rather than convergently. Bureau of Agricultural Economics has prepared maps of rural cultural areas based on data such as "plane of living," "land use," etc. A food habits map, based on above type of research, might be useful to historian and administrator.

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* There was no opportunity for Dr. Oliver to review the summary of his remarks at the time of publication of this current report.

Dr. Herbert Passin (Formerly, University of Chicago, Chicago, Ill.): Based on a study already carried out in Unionville, Illinois, hope to provide a detailed cultural picture of dietary habits there—to be worked out with special reference to established cultural divisions within the area—Unionville, "the hills," the Negro bottoms, the "river-rat" communities and neighboring small towns. Unionville is cross-roads town of about 300 persons in Massac County, Ill.; has a school, three general stores and halfway between town and "the hills" two churches with associated cemeteries. Dominant topographical feature is Ohio River 2 miles to south; floods its valley every spring, destroying crops, homes, barns. Flood plain alluvial bottom land very fertile and is the chief locus of agricultural activities of the people. Once heavily timbered; still is to some extent—a factor in migration of large number of southern Negroes to area. Only small number of families, who have pre-empted mounds and ridges, live in bottom lands; most live on uplands and come down to work fields. "River-rats"—transient population of fishermen—live on banks of river or in houseboats; sometimes work as hired help during harvest but have no regular social relations with natives. To east on section road is New Liberty, town similar to Unionville. Hamletsburg, older but similar, lies to north and east. North of Unionville lie "the hills" which constitute both physical and social boundary. Scotch-Irish element there replaced by German element. Contrast with Unionville and other whiskey towns because of differential rate and character of acculturation. In Unionville two-thirds of families have lost land and depend upon sharecropping, day labor and WPA; in hills two-thirds remain small independent farm owners. In Unionville civilization accelerated by whiskey making; "the hills," opposing whiskey, have slower, more resistant type of contact. Hill people generally more conservative; consider Unionville lower class, slightly uncouth, and disapprove of ways of town youth. To east and west lie Negro settlements—Black Bottoms and Shady Grove. Greatest migration came after Civil War. Were farmers and timber workers. Sharp racial lines maintained. For majority, standards of living of Whites and Negroes are approximately the same. Negroes also depend on WPA, relief, sharecropping, and day labor. Now propose to make study of diet habits of area—establishing general character of diet, daily consumption, recipes, materials (to be turned over to Department of Agriculture for analysis). Will consider buying habits, attitudes toward "store foods," trading practices, availability of resources, ownership, production, cash income, use to which domestic animals are put. Subject of drinking as important for area as clay-eating. Scarcity and abundance (except as altered by WPA), hunting and gathering of wild foods, age and sex differences in food habits all important aspects. Broad statistical mean of food habits fails within any given area because of cultural divisions. Will try to separate out the differential cultural elements that are usually merged in a statistical average of dietary habits—will be advance toward a more significant and richly suggestive type of study.

Dr. Ruth Tolman (Formerly, Bureau of Agricultural Economics, United States Dept. of Agriculture): Interviews on food habits in 5 urban communities; 440 individuals interviewed on nutritional knowledge and food practices;

informal interviews used. 1) Quality of diet very crudely evaluated; used terms "high point" (21.6%), "intermediate" (51.1%), and "low point" (27.3%) (384 responding), rather than Dr. Stiebeling's "good," "fair," and "bad." Only rough approximation because quantities were disregarded and data often inadequate. 2) *Reasons given for diet choices.* Question of "why" people choose particular foods not a profitable one; replies often rationalizations. Significant that people do not know why they eat as they do. Reasonable to conclude that cultural and unconscious factors enter more into food choices than conscious ones. 3) *If you had a little more money each week would you spend it on food?* Replies to question significant because of number of people (67.9%) who said would spend extra money on things other than food—in particular on clothes. Tables 4 (*Which foods do you think people are not getting enough of?*), 6 (*Does anything happen to people who don't get enough vitamins?*), 8 (*What foods are richest in vitamins we need?*), 10 (*Character of nutrition information indicated by responses to three above questions*), and 12 (*Factors considered important in choosing meals*) show that quantity and amount of information revealed is actually very good. Only about 12% of responses conspicuously stupid or fantastic. Suggests discrepancy between information and practice. Both general and specific knowledge of what happens to people who do not get enough vitamins is fairly good. Courses in school or college, then personal contacts given as chief sources of information in regard to vitamins. Health and "doctor's orders" main reasons given for changes in food habits. Later tables concerned with views of the government's efforts and responsibility in regard to providing an adequate diet for those in need; 68% (of 440) believe in giving help of this kind. Breakdowns and cross-tabulations not complete. Table 24 (quality of diet in relation to age) shows more high-point diets for people under 30 years. Little difference in quality of diet in relation to sex. Table 27 shows more low-point diets at lower income levels. Differences corresponding to educational level are marked.

Dr. Stiebeling: Table 4, order of importance of food needs, suggests people will not get very far without further information and a change of attitude. Both education and quality of diet in part a function of income. Taking upper and lower groups spending same money for food, advantage of upper side will not be so striking as table suggests.

Dr. Cummings: What would be differences in this kind of survey between large and small cities? Much more publicity in large cities.

Dr. Esther F. Phipard (Bureau of Human Nutrition and Home Economics, United States Dept. of Agriculture) on a report prepared together with Dr. Hazil K. Stiebeling, also of the Bureau of Human Nutrition and Home Economics, on the magnitude of poor-diet groups: Report based on 2 large-scale dietary studies made by Bureau of Home Economics * in cooperation with other Federal agencies. 1) Study of diets of employed wage earners and clerical workers living in cities in 8 major geographical regions (data collected as part of an investigation made by Bureau of Labor Statistics to revise Cost of Living Index); did not include families that had received relief or that had incomes under $500. Over 4,000 weekly records of family food consumption included. Comparisons were made of quantities of food consumed and its nutritive value by region, season, and level of expenditure for food. 2) Conducted as part of Consumer Purchases Study (cooperative work of 5 Federal agencies to study consumption in relation to income and family composition), survey included non-relief, native-born families living on farms, in villages and cities. Included Negro families in Southeast. Analysis based on more than 5,000 records of food consumption for one week. Nutritive value of diets studied in relation to income, family composition, region and size of community. Findings of surveys reinforced by many smaller studies. *Facts about poor diets: More than a third of the families in the United States probably have diets that have to be classed as poor;* only one-fourth have good diets; remainder have fair diets. *Some families spend too little to obtain an adequate diet.* None of village or city families in North or West got good diets when spending less than $2.00 per adult unit per week for food. In Southeast a small proportion of white families got good diets for slightly less than this amount. Probably one-fourth of non-relief non-farm families included in Consumer Purchases Study spent too little for food to get excellent diet. No data on this point available for entire population, but proportion undoubtedly considerably more than one-fourth. *Many families spend enough but do not obtain an adequate diet:* three-fourths of non-relief families in villages and cities included in Consumer Purchases Study spent enough to get adequate diets. With expenditures above a certain minimum, diet depends on *how* food dollar is invested. *There are more poor diets among large than among small families:* among village and city families in North and West proportion that had good diets decreased as family size increased. *Large families spend less for food of each person than small:* at given income the large families are less well off than small families. *But at any given income level there is a wide range in food expenditures* even among families of the same size and composition. Helps explain difference of quality of diets among families similar as to income and family composition. *Poor diets are more prevalent among the lower income groups than among the higher.* But more liberal expenditures for food do not guarantee good diets. *Diets are better in the North and West than in the South*—because incomes and expenditures for food are higher in North and West. Where food expenditures are same, diet in South as good as elsewhere—true of both Negro and White families. *Poor diets are more likely to be found in villages and cities than on farms.* Among non-relief families included in Consumer Purchases Study, 35% of those in cities and villages, 25% on farms had poor diets. Superiority of many farm diets may be ascribed to large share (an average of about two-thirds) of food supply which is farm furnished—chiefly milk, eggs, vegetables. Question frequently asked: *What income will support the level of food expenditures needed for an adequate diet?* No simple answer to this. At 1938 price levels, families of two persons with incomes of $500-$1000 could purchase either low cost or moderate cost good diets described in "Planning for Good Nutrition," *Yearbook of Agriculture,* 1939. Families of 5-8 probably would require incomes of $1500-$2000 for same diet. Among farm families as much depends on success in home food production and food purchases as upon cash income. *Summary:* In general, quality of diet is determined not only by economic resources in relation to family size but also by the wisdom and economy with which resources are used with reference to nutrition.

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* The Bureau of Home Economics was merged into the Bureau of Human Nutrition and Home Economics February 21, 1943.

Discussion: It was pointed out that better diet on farms may in part be due to work of Farm Security Administration and Extension Service and that there should be corresponding help given to people in towns.

Dr. Stiebeling: Not all farm diets good—only the average. Fully three-fourths of Negro families on farms had incomes under $1000 a year (in cash and in kind). Dietary standards used for measuring adequacy comparatively low and no deductions were made for kitchen or plate waste or for cooking losses.

Dr. Phipard, in a report prepared together with Dr. Stiebeling on technical material on which to base practical educational program for the homemaker in the low-income level: Large quantity and variety of material available, each piece adapted to particular group for particular purpose. *Food budgets for village and city families*—materials prepared to help homemakers plan economical and adequate diets. *Diets to fit the family income*—a 38 page bulletin giving diet plans at four levels of cost and nutritive value; work for maximum flexibility. *Getting the most for your food money*—a 4 page leaflet with illustrations to help in food selections; designed for low income families—weekly market lists for adequate diet at minimum cost and another for emergency use. *Family food budgets for the use of relief agencies*—leaflet prepared in 1933 to aid welfare agencies in working out relief allowances; two cost levels—minimum cost adequate diet and emergency diet. Similar material worked out by relief agencies with special emphasis on low cost foods available in locality; follow through with market orders, menus, recipes; often translated into Italian, Spanish, etc. *Food budgets for farm families*—in nearly every state Extension Service together with State Agricultural College promoting "live at home" programs designed to help farm families get as much of food supply as possible from farm; integral part of Farm Security Administration. *When disaster cuts down home-grown food*—leaflet prepared jointly by Bureau Home Economics, Extension Service, and Children's Bureau, to help families adjust to devastation caused by droughts or floods. *Nutrition education*—some contained in all above publications; other material in *Good Food Habits for Children, Food for Children, Milk for the Family,* and in publications on food buying and preparation; also in *Consumers' Guide* which goes to 120,000 families and family agencies; also the *Market Basket,* a 2-3 page leaflet issued weekly by Office of Information, Bureau of Human Nutrition and Home Economics. *Movies; film strips* prepared by Extension Service, Public Health Service, private agencies, and business groups.

Dr. Clark brought up discussion of ways of providing a cheap diet containing adequate vitamins, particularly education to new forms of food.

Dr. Stiebeling: Possible to work out synthetic diets, but new and strange things cause definite reactions against them.

Dr. Clark: One job of scientific group is to lay out cheap but optimal diet.

Actual sore spots in diet ought to be cleaned up. Should raise issue of prices of vitamin C, calcium, and vitamin B and map out low cost diet with enough of these elements.

Dr. Benedict: At Massachusetts Institute of Technology they say they can provide a year's food for $1.65, but in small competitive package you pay 35¢ for small amount. Job for economists.

Dr. Likert: Mark-up in prices a problem. Must discover ways of meeting need, then matter of preparation, then how to get people to use it—this last is our job.

Dr. Stiebeling: If very low cost and monotonous diet worked out, would you get people to eat it?

Dr. Likert: If worked out with alternate choices to suit neighborhood, should be tried.

Dr. Cummings: Must also take seasonal changes into account. But must educate people to use acceptable foods.

Dr. Clark: Soy bean meal has been tried. Spread through a county and a state in 6 months. Committee should try to get press behind such campaigns.

Dr. Wilson: Opportunity for research on phenomena on national scale—attitude of people to enriched bread. Millers said people would not eat whole wheat bread. Millers surprised to note increasing demand for whole wheat bread or long extraction bread—attribute this to commotion about vitamins. Would be interesting to study consumption. Don't know how much increase exists, but could find out.

Dr. Benedict: Might be tied up with good, going concern for nutritional education. Might give general information useful elsewhere.

Dr. Cummings: With knowledge of results of certain methods, could employ them in other directions.

Dr. Likert: Outlines an increasing responsibility for this Committee.

Dr. Stiebeling: Some changes are considerably more difficult than just changing from white to enriched white bread.

Dr. Clark: Against even experimental work on subject if there was any possibility of harm in any of suggested diets.

Dr. Stiebeling: We are now engaged in making a study of spending and saving in rural families in wartime. This will provide data on incomes, savings, and expenditures for living in the year 1941 and for the first quarter of 1942. In addition to information on expenditures for food there will be estimates of the quantities of food consumed in the spring of 1942 by different income classes and information on home food production programs both in the spring of 1942 and for the year 1941. Report of comparison of milk consumption of families participating in the 5¢ milk program with consumption of families not participating. Tried to study same 1000 families before and after campaign, but at time of second survey only 624 families of original 1000 families still at same address. Original group included all families of two or more persons eligible for relief; did not include one-person families, aged or blind. Before program went into effect White families bought 1.63 quarts per person per week at 11¢ per quart; Negro families bought 0.81 quarts per person per week. Half of eligible families included in sample participated in program. Found consumption of fluid milk in White families doubled, actual expenditures went up 24%; in Negro families consumption tripled and actual money outlay went up some. During August one-fourth of all eligible families in District participated; about half of eligible families of 2 or more participated. *Washington Post* suggests any low income family should be allowed to participate, including all WPA.*

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* Available reports:

U. S. D. A. 452 MP. Family food consumption and dietary levels. Urban and village series. 30 cents.
U. S. D. A. Leaflet. 3 market lists for low cost meals. Single copy free; $1.25 per 100.
U. S. D. A. Leaflet. Market lists for moderate-cost and liberal meals. Single copy free; $1.25 per 100.
U. S. D. A. Cir. 645. Low priced milk and the consumption of dairy products among low income families, Washington, D. C., 1940. 10 cents.
U. S. D. A., AWI-1. Food for growth.

All above bulletins are obtainable from Superintendent of Documents of the Government Printing Office, Washington, D. C.

CONTRIBUTIONS FROM THE FIELD OF MARKET RESEARCH *

JUNE 27, 1941

Wesley Hardenbergh (American Meat Institute): Institute comprises 375 meat processing companies. Began investigation and campaign because of downward trend of meat consumption. Important to Institute, to farmers (25% cash income from selling meat animals). Hoped to discover consumer attitude.

Elmo Roper (Consultant to American Meat Institute): Survey of meat consuming habits; motives for eating; motives for not eating. First step—rocking chair conversations with consumers, home economists, doctors. Second step, questionnaire pre-tested in 30 communities. Third step: 5200 interviews using questionnaire on *Fortune* cross-section, interviews with dieticians, home economists, domestic science teachers, and observers in butcher shops. Findings: 98.8% of all interviewed ate meat at some time, 36% said it tasted best (of long list of foods), 80% labelled meat as food that stayed with you longest; 60% of all evening meals contained meat, 50% noon meals, 33% morning meals. *Differences:* Men ate more than women, manual laborers more than white collar people. Meal at which meat eaten: South and Southwest—fairly heavy at breakfast; South and Northwest, heavy at lunch; all except Southwest heaviest at night; rural heaviest at breakfast and noon; urban, heaviest at evening. Meat preferences: lamb consumption largest in Northeast, smallest in Southwest (though area where lamb grown); 95% ate beef at some time; more pork than beef meals, though more people actually avoided pork than avoided beef. *Drawbacks to meat consumption:* 21% thought meat hard to digest; 75% (men and women equally) thought pork most difficult of the meats to digest; 50% believed some or all meat fattening. Although 30% did something consistently to get vitamins in diet and 4% women considered vitamins most important in meal planning (9% considered proteins most important; smaller % minerals), meat does not rank as important source of vitamins in public mind—6% said meat best source, 16% said meat contained some vitamins. Doctors and dieticians better informed but disagreed among themselves. Considered meat an important source of proteins, but these not generally regarded as so important in meal planning. Some 20% felt they ate too much meat. Comparisons of records kept by one-fifth of respondents with statements made showed they actually ate meat 1.4 times daily; thought they *should* eat meat 1.4 times daily; thought they *did* eat meat 1.7 times daily. Doctors and dieticians thought rich eat too much, poor too little. Actually, despite differences of quantity and quality, each group eats meat same number of times. Majority said meat "most expensive food" for what you get out of it; easily understandable since it is not regarded important source of vitamins and is considered by so many as indigestible. Thought by 13% that beef, if eaten more than once or twice a week, would cause high blood pressure. Those eating meat infrequently, when asked why, said they did not feel need of it. Reasons given by 20% who felt too much meat eaten: keeps one from eating vegetables and other things "good for one;" hard to digest; bad for blood pressure; bad for kidneys; fattening. *Main factors affecting food-eating habits:* economic status and geography (far more than sex). Cereals, breads, meats showed practically no variation in amounts consumed in different economic levels; consumption of fruits and juices (fruit and vegetable) declined sharply with decline in economic level. Tabulations of records of food eaten made only of meat consumption.

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* See minutes of the conference of Committee on Food Habits, June 27, 1941, under same title.

Mr. Andrew Duncan (Leo Burnett Company): Worked out advertising campaign for American Meat Institute. Carried research further to find what housewife means by "well-balanced" meal; what people mean by "hard to digest." Decided groups which must be reached: 1) thought leaders in field of nutrition (doctors, dentists, nurses, nutritionists)—special campaign couched in their own language necessary for these; 2) home economics teachers; 3) retailers and salesmen contacting retailers (about 2,000,000 people behind counters of some 500,000 retail outlets); 4) 130,000,000 consumers in 35,000,000 families. *Media used to reach consumers:* well-rounded list of national magazines can cover up to 75% of population (lower third—*True Story, Liberty;* middle third and upwards and downwards—*Saturday Evening Post, Life, Colliers, Good Housekeeping, Ladies' Home Journal, Woman's Home Companion, McCall's*); newspapers (reach lower in economic scale); radio; outdoor and transportation advertising. *Approach to appeals:* must bring appeals down to family level; deal with problems of misinformation about meat; tell correct nutritional story of meat; teach women cuts of meat (in an earlier study found women generally knew only 12-15 cuts out of possible 260) in terms of expense and thrift.

Mr. J. H. Moninger (American Meat Institute): Described presentation of data to public to correct misinformation and give new information. Positive points uncovered in Roper survey: people eat and like meat; public recognizes meat has a satiety value. Negative points: public does not know about vitamins in meat; think meat difficult to digest, fattening, expensive, too much is harmful—causes variety of ills. Checked presentation with nutrition authorities before sending it out to public. Showed numerous poster and chart exhibits to illustrate points. In messages to physicians answer four negative criticisms: vitamins, fattening, indigestibility, eat too much. In messages to home economics teachers add other points—economy and preparation. In messages to general public stress: vitamins, digestibility, waistline (importance of meat in modern reducing diet), satiety value, economy (show this without pointing directly to fact that meat is not expensive or that it is economical), leftovers (must take into consideration men's instinctive dislike of), appetite stimulation by advertising appeal, reply to "eat too much" by showing meat in well-balanced meal. In addition to direct advertising also send material through publicity channels; these may coincide with ad trend or be more general in nature. As campaign goes on, fits more and more into broad program of nutrition.

Mr. R. C. Pollock (National Live Stock and Meat Board): Board established 18 years ago. Is independent of but cooperates with American Meat Institute. Uses research facilities of Bureau of Home Economics and state experiment stations; research projects largely in hands of the National Research Council. Board has own Department of Home Economics under Miss Inez Willson. Make regular surveys on cost of meat. Last survey in Chicago showed 225 retail cuts at 25¢ a pound or less. Gradually enlarged research program; Miss Anna Boller in charge of nutrition division.

Miss Anna Boller (National Live Stock and Meat Board): Board carries on two types of research: fundamental research and clinical research. Includes such studies as: value of protein foods in reproduction and lactation; blood regeneration; iron content of animal tissues; fat metabolism; unsaturated fatty acids; effect of different percentages of proteins in diet; effect of meat on biological value of proteins; effect on kidneys of diets high in protein; vitamin B complex; meat and disease; high protein diet in hypertension; lunches high in iron—effect on hemoglobin of under-privileged children; high protein diet in weight reducing and gaining—complete metabolism work; lard and eczema; anemia in infants and in college women. Open to suggestions for studies to be included in program for next year.

Mr. Pollock: Board has approved a study of loss of vitamins in meat as a result of cooking. Board ready to cooperate with national health defense program. Are working with retail meat dealers to help them sell housewife less expensive cuts of meat. Merchandising Department now working with Army on meat problems.

Mr. Max Cullen (National Live Stock and Meat Board): Merchandising Department uses demonstration as chief method of instruction. Work of department divided into 5 sections: meat lectures (with demonstrations); meat exhibits at livestock exhibits and fairs; merchandising service (technical information for authors, editors, publishers); motion pictures; training program for Army, Navy, and Conservation Corps. Try to help housewife select meat to better advantage. In demonstrations find relative importance of appeals to senses as follows: eye, 87%; ear, 7%; nose, 3.5%; hand, 1.5%; tongue, 1%. After demonstration give booklets describing subject (*Cashing in on Pork, Cashing in on Lamb, Cashing in on Beef,* etc.); include little reading matter, many pictures. Last year installed 138 exhibits across country; found people spent anywhere from 3-20 minutes observing exhibits and taking notes on cuts, etc.

Mr. Pollock: Should consider possibility of tying defense program to media used by Board—exhibits, for example. Home Economics Department distributes information regularly to 240 out of the 800 radio stations in United States on meat—selection, preparation, and utilization of food. Supply consumer literature for distribution. Maintain "clip-sheet" service on meat for 102 metropolitan newspapers. Sell (10¢ a copy) textbook *Ten Lessons on Meat* to high schools. Monthly bulletin, *The Food and Nutrition News,* sent out to home economists with samples of other new literature. Home

Service Department conducts cooking schools (emphasizing well-balanced meals) across country. Give supporting copy to newspapers. Women in charge also speak over radio. Syndicate service sends out copy weekly to about 122 papers—emphasis on less demanded and low cost cuts of meat. Second syndicate service at present going to another 116 papers—are furnished with glossy prints of material on request. Since first of year have been cooperating with Army. Merchandising men visited Army camps to observe problems involved. Assist Army with cutting, cooking, and on nutrition; not too much on cooking; nutrition material taken from Government bulletins; cutting methods entirely new.

Mr. Cullen: Observation showed necessity for developing entirely new methods of meat cutting for Army to get uniform sized boneless roasts. Took information to mess sergeants and cooks. Made complete round of all large Army posts in the 9 Corps Areas. Conducting 5 day meat training schools with key man from each regiment in attendance at the post school. Each returns to regiment as meat specialist. By August 15th, 800 such men will have been trained. Prepared supplementary booklet, *Meat Reference Manual for Mess Sergeants and Cooks.* Prepared large lecture charts: 1) three functions of food and food classifications (made with cooperation of Col. Howe); 2) nutritional requirements of properly balanced meals; 3) meat cookery; 4) meat cutting series; 5) location and names of wholesale cuts in various kinds of meat; 6) meat carving; 7) refrigeration, sanitation, safety, care of meat blocks and tools. These are for use in Army Bakers and Cooks Schools. In addition, give men handbook with necessary references to put into practice information obtained at lecture demonstration.

Mr. Pollock: Board has prepared booklet on lard for Army use—how to use and make different products with lard. Lots of pictures with very simple directions. Board has had prepared a motion picture on cuts of meat, methods of cooking, methods of carving, and what there is in meat and what it will do for you. Since distribution began (Dec. 1, 1940) picture shown 11,893 times to 2,422,256 persons, approximately 60% high school and college students, 40% adults.

Mr. Hardenbergh: Offered cooperation of Meat Institute with program.

Discussion following formal reports:

Mr. Roper (in reply to question of Dr. M. Seay on breakdown of figures in economic levels of survey): Breakdown in terms of size of place, geographical area, section, age, economic level, but do *not* have tabulation of a particular economic level in terms of size of place, etc. Have an over-all picture of rural area as compared to other size groups. Do not have, but could get, rural areas by geographical areas, or economic levels, etc. Can give diet all the way through for an average day.

Dr. Hazel K. Stiebeling: Farm family food consumption report gives by family size and income for different sections quantities of food consumed during a period of a week.

Mr. Roper: In speaking of rural families in report, farm and non-farm are lumped together but could be separated. Percentage of relief families included in survey. Don't know effect of food stamp plan, but would throw figures off only for a small percentage of over-all. The survey was an accurate cross-section of the entire population—geographical area, size of place, sex, occupation, age, and economic level. Have several methods of checking. Booklets not returned in proper proportion (more rich and old replied) but threw out enough to get accurate sample of 1000. Not likely to do another survey soon because habits change slowly, but the war situation with its rapid changes may make it necessary to check up.

Mr. Pollock: Rapid changes illustrated by Army. In past little lamb used. Mess sergeants claimed soldiers did not like lamb. But survey made when lamb was served at two Army camps (13,000 men) showed men 100% in favor.

Dr. M. G. Reid: Posters shown here presumably dealt with attitudes revealed in survey. What was response to digestibility? Question whether people mean feeling of discomfort or whether they mean absorption of food when they speak of digestibility.

Mr. Roper, Mr. Burnett: Don't know exactly what people do mean; advertisement tries to deal with both factors.

Miss Willson: When people say a food is indigestible there is the question—how many speak from experience of actual digestive disturbance due to a food? Probably a very small proportion.

Dr. W. H. Sebrell: An important point in advertising. May do harm if miss point. Attitude probably partly due to recommendations of physicians for feeding of invalids or babies.

Miss Boller: Publications of National Live Stock and Meat Board stress fact that some meat (those higher in fats) are more slowly digested rather than a difference in actual digestibility. Must begin with education of doctors on this.

Dr. Reid: But is there in fact any difference in digestibility? Advertising of business groups shows some unwillingness to face up to something that is a disadvantage to an actual product. Reaction to a single advertisement conditioned partly by other advertisements, etc. Evasion reduces educational value of posters. Recognition of limitations necessary if educational contribution not to be wasted.

Mr. Moninger: Statements are first submitted to Council of Foods and Nutrition of the American Medical Association for their approval.

Dr. Reid: Nevertheless attitude of public may be sceptical.

Dr. W. L. Warner: Important thing for Committee to know is where do you succeed and where have you failed. What kind of things do you do that really get people to follow what you want them to do? . . . . What sort of things have you done that don't get the follow-up you would like?

Mr. Roper: Must start with analysis of whether emotional reasons for doing something are for you or against you (in making up advertising or propaganda). In meat situation have two strong emotional reasons for you (keeps you from getting hungry, tastes good) and a number of rational reasons against you. Must provide rational reasons which will dispel fears—must understate rather than exaggerate. If a strong emotional urge to do something is missing, then must combine thing with something else to provide the emotional support. (Defense Bonds—no strong emotional urge to save money—so must combine with do something for Uncle Sam). In general there is a tendency to overestimate amount of information common man has, underestimate his common sense. Successful appeals are those which are sound statements, understatements rather than exaggerations, directed toward person's actual self-interests. These statements backed up by eight years of research on subject.

Mr. Leo Burnett (Leo Burnett Advertising Co.): Emotional urge plus rationalization the basis of all successful advertising. Must appeal to self-interest of reader. In nutrition program have problem of articulating the standards and yardsticks. Must boil down points and put them where everyone can see them. Changes probably greatly accelerated in present situation. Must find necessary emotional appeals—"everybody is doing it" and patriotism probably would be successful. Two major divisions of problem—craftsmanship (words, pictures, technique) and media. Should not depend solely on manufacturers, etc.; must find ways to adequately place, focus material.

Mr. Pollock: Must interpret scientific data in such a way that the layman or instructor can understand it. Story must be sound and reasonable. For instance, research on liver as source of vitamins eventually resulted in tremendous increase in sales of all kinds of liver. When lecture on liver is given in cooking school, all liver in town is bought up next day. And so on. In material on reducing or gaining diets, urge person to consult physician first. Experimented with diets for reducing including lean meat. Checked effect of high protein diet on dogs and rats. Issue of *Harper's Bazaar* containing data on "Reducing with Meat" sold out; had to repeat article. In building up a campaign must put emphasis on sound facts; against kind of advertising that says "eat more," "drink more"—never urge people to eat more meat. A program in Kansas City, Omaha, and St. Louis stressing forequarters completely changed sales in two months. Education on cooking temperatures of meat went slowly but now average woman knows low temperatures should be used. Got cooperation of Taylor instrument people when they made a meat thermometer. Must make information simple if it is to be used. Concentration necessary on defense program. Commercial interests and educational institutions should go ahead hand in hand in interest of civilian and national defense. Put available material in shape the layman can understand. People are eager for new information. Research on lard and eczema not complete—but people already asking for help.

Dr. R. Wilder: Does acceptance by the Council on Foods of the American Medical Association add to the value of an advertisement? Helps with Food and Drug Administration when American Medical Association standards are accepted. Must make one or two points of criticism. Meat eating may not cause hypertension, but most physicians would hestitate to allow a person with high blood pressure or nephritis, etc., to eat a lot of meat. Might be kickback on this advertising point. Another thing, approximately same number of calories needed in summer as in winter, but in summer don't want foods with a high specific dynamic action, and meat is high.

Mr. Pollock: People don't write in on such points. But need advice and counsel of people like you.

Miss Boller: Statements based on editorial in *Journal of the American Medical Association*. Meat does not cause elevation of blood pressure in uncomplicated cases of hypertension. But have laid little stress on point.

Mr. Burnett: American Medical Association seal strong point in advertising; appeals to retailers especially.

Dr. Seay: Are we giving enough recognition to importance of elementary schools—20,000,000 people in elementary schools not yet reached.

Dr. C. E. Guthe: Discussed problem at previous meetings—relative level of reading ability and vocabulary of group for whom material intended.

Dr. R. Tolman: What is relation between correct information and correct action?

Mr. Roper: Information not tabulated—complicated by economic factors. Must get cross-ruff between amount of education and purchasing power.

Mr. L. D. H. Weld (McCann-Erickson Advertising Agency): Handle Pillsbury Flour advertising. No new surveys made. So far largely newspaper advertising on vitamin reinforced flour. Too early to tell results. National Biscuit—new bran. Testing appeals. California Walnut Growers account—advertising—magazine, newspaper, outdoor, recipe books—increased consumption and length of season. Pineapple Association account—well rounded campaign almost doubled sales of crushed pineapple. Shows habits not too hard to change. Media used for educational work depend on product, group to be reached. Magazines do not reach lowest income groups; reach these by radio and newspaper; some outdoor advertising. But no general answer. Importance of research work in planning campaign—various forms: broad consumers surveys, home tests needed to determine appeals and consumer attitude toward product. Developing special techniques. No check when advertising has begun—except possible later sales survey.

Miss Marietta Eichelberger (Director of Nutrition Service of the Evaporated Milk Assn.): Evaporated Milk Association organized in 1923 for research and education. All research carried on through fellowships. Method of interpretation of research depends on group to be reached; tools for home economists, science, or grade room teachers, teachers of adults, public health or welfare administrators, doctors, dentists, nutritionists, nurses, etc. Need for simplified interpretation. Evaporated milk—cow's milk—illustrated by poster. Evaporated milk a product, not a brand. Educate teachers to teach clients, etc. Publications carry seal of American Medical Association, sometimes important, sometimes not. Non-technical language essential. Developed series of welfare leaflets—education material followed by recipes—simple everyday ingredients—*How to Feed Children in Nursery Schools; How to Feed Young Children in the Home* simplified into *Some Foods for Your Child* simplified into *Feeding Your Child. Feeding a Family at Low Cost* simplified into *Using Evaporated Milk in Good Food for the Family.* Educational material must be attractive—color, if possible two colors, pictures, white space, no crowding. Also plan teaching aids for use in school room—posters, stories, comic strips, plays, recipes, suggestions for activities.

Several units of study on problem basis all showing evaporated milk as an economical, safe milk supply. Foreign language leaflets (Italian, Spanish, Yiddish) developed but not worth effort and cost. Consumption increased from 7 pounds per person to 18 pounds per person over 20 years. Try to overcome prejudice against food in cans; taste prejudice—children's prejudice due to adult influence. Use evaporated milk in nursery schools, school lunch programs—convenient as well as safe. Good acceptance. Leaflet on school lunches for WPA program. Always stress economy, safety. Infant feeding program—result of early work of late Dr. Marriott—approximately 10% of all babies in United States consume evaporated milk; do not need to be educated to like it. Evaporated milk more easily and completely digested; calcium, other minerals, and vitamin values not impaired. Have no way of knowing exact distribution of evaporated milk or who gets it in home; would like to know. Approximately 60% now produced is reinforced with Vitamin D—approximately 50% by means of irradiation, 10% by adding fish oil concentrate. No data on sales appeal of each type.

CONTRIBUTIONS FROM THE FIELD OF CHILD DEVELOPMENT [*]

JUNE 28, 1941

Miss Mary Sweeny (Merrill-Palmer School): On a study of changes in family food habits by Merrill-Palmer staff. Included only protective foods listed in Govt. Bull. *Eat the Right Food.* Submitted to faculty of Merrill-Palmer School, Merrill-Palmer students, an evening class of students at Wayne University, Merrill-Palmer parents, parents of WPA nursery school. Asked: 1) if adults had changed habits; 2) conscious change; 3) frequency increased or decreased; 4) why changed. Changes: M-P staff, 40%; M-P students, 21%-36%; Wayne U., 50%; M-P parents, (f) 50.5%, (m) 44%; WPA parents, 32.8%. *Reasons:* education (highest all groups); medical advice; change in environment; change in taste and ways of preparation; reducing; professional connections; social reasons. *Media by which reached:* articles, lectures, classes, profession, noteworthy few radio and no advertising. *Actual changes:* (men M-P)—grapefruit and dark bread; also oranges, white bread, cheese, cereals; same for M-P women; (WPA parents) high in protective foods, especially milk, cereal, oranges, grapefruit, decrease in sweets; (no occupation group) milk, grapefruit, oranges, meat, cheese, vegetables, fish. In dealing with data did not separate favorable from unfavorable changes, but it could be done. Question of whether people really not influenced by radio, or just did not mention because of lack of prestige. Did not deal with any factors of environment or background such as income, nationality, etc.

Dr. George D. Stoddard (State University of Iowa): Read abstracts from four researches, selected from bibliography of 30-40 titles on changes in food habits of young children. 1) K. Dunker: "Experimental Modification on Children's Food Preferences through Social Suggestion" in *Journal of Abnormal and Social Psychology,* 1938, 3. Conclusion: There is a tendency to learn to like what is accepted, but liking or disliking always subject to social suggestion. Control group of children made free choices of some foods; same children in pairs chose—choices of second child of pair showed 55% due to social influence—younger (if more than 2¾ years) followed older unless older an adult where might get respect barrier. Story telling experiment showed children liked (relatively) unpleasant hero food better than (relatively) pleasant hero poison; influence tended to survive original situation though gradual tapering off took place. 2) D. McCarthy: "Children's Feeding Problems in Relation to the Food Aversions in the Family," in *Child Development,* 1935, 6. Conclusions: Food aversions of family members associated with 35% of children's food aversions; problem group had more similar aversions than non-problem group and also had more peculiar or unique aversions. Higher percentage of identical food aversions among siblings than between children and parents of same group. 3) T. F. Vance: "Food Selections of Nursery School Children," in *Child Development,* 1932, 3. Forty-four children, 25 observations each, choice of meat or eggs, 2 vegetables, sandwich. Meat, apples, sandwiches, fish, eggs ranked high; vegetables low; creamed foods low. Single items preferred to combinations. Taste factor, (emotional) conditioning and mechanical difficulties rank high in reasons for choices. Similar study comparing city with rural children showed different accepted foods for each group but all preferred white and dark bread, milk, custard, carrots, peas, and beans; most disliked common vegetables; rural children had better appetites. 4) G. M. Borgeson (Teachers' College dissertation) on observations done in WPA nursery school showed that factors involved in getting children to eat included: watchful neglect; pleasing atmosphere; social conversation; small portions; paired liked-disliked foods; matter of fact attitude to refusals; good adult example.

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[*] See minutes of Committee on Food Habits conference of June 28, 1941, under same title.

Dr. Arnold Gesell (Clinic of Child Development, New Haven Hospital): On studies of development of young babies under elastic conditions of self-regulated feeding. Organism taken as point of departure; organism and cultural factors united in concept of development. Babies in homes; mothers charted feeding, waking, sleeping periods over long time. Found self-regulatory fluctuation in all three factors; interpreted as effortful attempts of organism to accomplish increasingly mature adjustments. Range of fluctuation varies with infant; those with low variation fit best the usual fixed schedules. Self-demand schedules satisfy infant physically and emotionally; sense of security essential to mental health. Expresses democratic approach to problem. Emphasis on meals changes with age: 0-3 months night meal; 3-6 months breakfast; 6-18 months noon meal; 2-3 years night meals; 4-5, 6-12 breakfast. Waves of appetite and allergies affected by maturity factors. Posture important. *Dr. R. Benedict* cited examples from primitive cultures showing agreement with Dr. Gesell's findings; pointed out association between nursing and sense of security. Dr. Gesell emphasized same point in relation to self-selection. *Dr. Stoddard*—question of foods chosen; must be good foods. Asked how much choice given infants. *Dr. Gesell* said not much experiment on this but also emphasized good foods; referred to Clara Davis chapter in Vol. I of Brennemann's *Practice of Pediatrics. Dr. W. L. Warner* asked how all this was related to improving of general food habits. After some discussion *Dr. Gesell* pointed out that the habits formed in first five years are vital; at present child participation in family meals (normal way) has declined. But diets are better. Getting enough choices of food to all people a problem of technology. Wrong feeding in early period creates a continuing cultural difficulty. Therefore must emphasize prevention rather than re-education of adults; must set up ways of living in homes which will give organisms best chance to thrive from beginning.*

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* Gesell, Arnold, and Ilg, Frances L. Feeding behavior of infants: A pediatric approach to the mental hygiene of early life. Philadelphia, Lippincott, 1939.

Gesell, Arnold, and Ilg, Frances L., in collaboration with Learned, Janet, and Ames, Louise B. Infant and child in the culture of today: The guidance of development in home and nursery school. New York, Harper, 1943.

Dr. C. A. Aldrich (Children's Memorial Hospital, Chicago, Ill.): In the newborn, cultural changes have made little difference in their inherent abilities developed over the whole period of human evolution. Importance of selective behavior related to question of habits; habits are based on satisfactions—things we like to do—but in children are a more reflex sort of behavior. Habits can be positively or negatively inclined—if against real satisfaction cannot be good habits. Therefore appetite must be allowed free range in selection. Animal experiments and studies of children's choices show ability to make necessary choices for balanced diet. Selection of good foods show children will normally not select nutritionally forbidden foods (sugar, etc.). Dr. Young of University of Illinois has theory taste buds may register deficits and so aid selection. Babies need few different things to eat (as few as 6-7 kinds even to 4 years). Growth determines time children will accept new kinds of foods (semi-solids physically difficult before 4 months). But must not limit diet to what we now know is good—may find more foods later. *Dr. Seay* asked whether program should first stress right foods of economic conditions. *Dr. Aldrich:* Information not enough; thwarted appetites lead to problems; must help all the time to develop right habits from beginning. Research in Toronto on effect of protective foods given to pregnant mothers shows correct feeding (costing $200) will cut infant mortality. *Miss F. Stern:* How are mothers induced to follow good program? *Dr. Aldrich:* By getting mothers to see child growth and development and to understand that pediatrician and mother only provide favorable environment. Demonstrate time for changes in diet by development of child itself.

Mrs. Adeline Heiney (National Child Research Center, Washington, D. C.): In work with pre-school children (70-80 a year) one difficulty is analyzing likes and dislikes and giving right amount of cooperation in feeding problems. Some children have established dislikes; others suddenly change likes (especially after 4 years). One group disliked vegetables; decided to allow complete free choice; after 3 weeks discussed minimums with them and within 2½ weeks got cooperation in eating rejected foods. Method also successful with 5 year olds; not with 3 year olds. Selection must be guided by some set minimum. *Dr. Aldrich* pointed out necessary differences when work is therapeutic rather than (as his) preventive. *Dr. Stoddard* said both points of view necessary; task of Committees to find what influences on food habits prevail in modern culture. *Dr. C. E. Guthe* said object of both Committees so to integrate human animal with opportunities that we will get best results. *Dr. Benedict* said important to find ways of working from beginning but also to correct bad existing developments. *Dr. Aldrich:* Of course, but ought to make use of findings of science. *Dr. Gesell:* But human organism itself ought to be center of gravity for all work.

Dr. Miriam E. Lowenberg (Iowa State College): Interested to discover why children in Dr. Vance's study rejected vegetables. Experimented with effects of changed methods of preparation; found children rejected strong tasting vegetables (onions for one); textures also important—object to stringy or dry foods, gummy and starchy foods. If prepared to have mild taste and with good texture children would eat. No comparative studies on effect of family eating habits, but think they play part. In making changes important to begin with what child likes, only small portions of disliked foods; no forcing. Discarding the cooking water may cause a loss of nutritive value but felt it more important first to develop a taste for food itself.

Dr. Mary V. Gutteridge (Formerly, Merrill-Palmer School)*: On relative value of two methods of conducting lunch procedure. Two groups of children, 8 in each, ate in separate rooms. In first, children served selves; in second were served but allowed to choose second servings. Observed by 6 graduate students—estimate of food; amount eaten by each child each item; amount left uneaten; time taken to eat; child's behavior and conversation. In computing found three major variables: individual differences (average of top child more than twice amount of bottom child); differences on five days of week (Tuesday lowest, then Wednesday, Thursday, Monday, Friday); week to week differences (general increase due to outdoor play as spring advanced). Found mean amount consumed by self service exceeded that by control group. May point to cause of difficulties with small child in keeping him on a strictly regulated meal schedule. Are hoping to carry experiment out where can check all meals taken in a day.

Excerpts from letter by Dr. Willard Olson (University of Michigan): Expresses doubt habit approach gets at some roots of problem; verbal expression of attitude seems to have relationship to organismic status of child (center of gravity of a series of measurements) in relation to chronological age. Attention should be given to affective and emotional aspects of food consumption; recognize relationships to growth of child as a whole.

Dr. Benedict: Above experiment too limited to allow one to draw cultural conclusions; ought to have experiment using children of different cultural backgrounds. *Dr. Stoddard:* Food only one means of expressing resistances in nursery school ages. Ought to carry out studies of 2, 3, 4 year olds to higher age ranges. Must also consider economic selective factor—in orphanage where poorly fed, children eat everything offered. *Dr. E. Waring:* Loyalty strong in children of nursery school age. Can set up contract—joint goal with adult and so accomplish necessary task (eating).

Miss Agnes Larson (City Supervisor of Home Economics, St. Paul, Minn.): The object of our nutrition work in the City of St. Paul is to locate undernourished children, overcome malnutrition, prevent further deficiency through dietary measures; correct through medical procedures. Much of the work was carried on in the school in order to reach all pupils and through them their parents. Work was also carried on in the individual homes. Monthly classes were held for parents at school, and classroom instruction was given to the children in school by their own classroom teacher. Feeding and care only effective if accompanied by corrective measures. Problem of 500 Mexican families on very limited diet—which children accept; show no interest in other food until placed in nutrition clinic or influenced through home visitation. Conduct lunch services in schools; also nutrition clinics; nutrition classes for parents, for children; home visitation work. Made servey of influence of nutrition clinics on food and health habits of undernourished children. Using as controls 40 children from two schools. Observations and measurements by students of nutrition at University through home visitation; contacts with social worker, teachers, physician. Must have home cooperation to succeed. Must also get children to cooperate willingly. Economic status of family influential (larger the family on low income, worse the situation). Made thorough tests of children at beginning of experiment. Allowed children to follow own wishes in eating lunch when started; within four weeks almost all dislikes disappeared, table manners improved, appetite improved. Improvement in rate of eating, play, sleep, behavior at mealtime, and nervousness in over 40% of cases where formerly had difficulties. Degree of excitability and evidence of colds reduced. Scholarship improvement in 53%; attentiveness in 56%; posture in 66%. Reduction in mean percentage underweight from 12% to 7%. Right kind of illustrative material very necessary to put program across; prepare simple pamphlets for children, teachers, parents so that lessons can be followed through at school and home. No technical words. Can get going with foreign groups by praising what they have already done and go on from there—adding new things rather than making abrupt changes. Outstanding defects in children were anemia, defective teeth, tonsils, ear conditions, cardiac diseases; 35% had defects that had to be corrected before building up; 80% had low hemoglobins. *Dr. R. Wilder:* What success with foreign groups? *Miss Larson:* Italians and Mexicans problem, but get very good cooperation. Have six diet centers in city taking care of 300-400 families; 300 children eating at centers at noon. Since each family averages 5 people, work with all reaches large population—mostly foreign. Get commodities from Office of Food Distribution which is supplemented by funds for food obtained through local agencies.

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* There was no opportunity for Dr. Gutteridge to review the summary of her remarks before the publication of this current report.

Dr. Ethel B. Waring (Cornell University): Family Life Department stresses personality aspects of food habits. A study of 10 best eaters—10 poorest eaters seemed to show that "good eating is an aspect of development in that the more advanced organism seems more likely to be a good feeder." Feeding not only organism's effort to satisfy hunger, but also effort to satisfy social and affectional needs. Necessary to have people learn principles of guidance rather than merely practices, so they can apply the principles in either situation. Result of film material shown in Farm and Home Week as experiment indicated parents liked to see parents learning and succeeding in guiding their children's eating better than hearing lectures about it. Prepared bulletins on children with food dislikes showing how these were overcome—idea to give principles for parents to follow: *what* parent did, *when* she did it, and related *what* with *why*. Tried to put over idea of relationship between parent and child—that principle will fall down if based on unwholesome relationship. Three categories of action: child and adult with joint effort and purposes; efforts opposed; efforts unrelated or independent. Under these categories illustrated if and when social pressure (adult step in) desirable. Plan small 4 page pamphlets simply written. Try to help parents feel less strain, more confidence. Give minimum first serving in school and advocate it for home—if child gets this amount into him, parent can rest easy about whatever else is chosen. A study of method in influencing food habits of low income families—instruction given in home visiting was effective. Follow-up showed improvement persisted.

Remainder of program devoted to educational programs and their orientation.

Miss Sue Taylor (Federal Security Agency, Department of Agriculture): Federal Security Agency is the action agency set up in the United States Department of Agriculture to help low income farm families who are unable to secure a loan from any other lending agency; it has given rehabilitation aid to some 900,000 families. The method is one of loans based on farm and home operating plans, supplemented with education in the necessary practices. It is a "supervised credit" program. Federal Security Agency farm and home supervisors visit farms and homes of borrower families to discuss their problems, analyze their resources, and develop with each family a farm and home plan which will include: 1) production of adequate food for the family, 2) feed for livestock, 3) diversified farm enterprises for cash income, 4) farm and home operating budgets, 5) improved farm and home practices which will lead to an improved level of living for the family and greater financial security.

Making home-grown food available has been the greatest single factor in improving food habits which have resulted in improved health of Federal Security Agency borrower families. This has been accomplished by planning with the families for adequate home production and giving them financial assistance and round-the-year, on-the-farm advice. Subsistence production of milk has increased from an annual 99 gallons per family before their acceptance on the Federal Security Agency program to 488 gallons; canned fruits and vegetables from 51 quarts to 242 quarts; meat from 85 pounds to 447 pounds; and the average family has had an increase of about 88 dozen eggs. Planning is based on individual family needs. Planning the food supply begins with the amounts and types of food the family should use each day and the amount they will need for a year. The next step is planning how much the family will use and what they will produce. Planning for home production is very complete. It includes the number of subsistence livestock, their feed, care, and management; an adequate supply of vegetables and fruits for use fresh, for canning, drying, and storing; and the necessary equipment and materials for production, such as good quality seed, insecticides, fencing for gardens, pressure cookers, jars for canning, and proper storage facilities.

Cooperative purchasing of farm and home equipment and machinery is encouraged among families who are not able to own it individually. Proper tenure arrangements are important to an adequate home-grown food supply. Federal Security Agency assists the landlord and tenant to draw up a lease that will encourage food production as well as cash crops. Assured occupancy for three to five years with written tenure agreements, recognizing the family's need for producing their own food, has led to more adequate gardens and more subsistence livestock on rented farms. Actual teaching of improved practices has resulted not only in production of more food but also in better variety, better quality, and better use of food. For example, some people do not want milk because they never had milk of good quality, some do not like carrots because they never learned how to serve them.

Care of food, how to plan, cook, and serve palatable meals has been an important part of teaching Federal Security Agency's families. In teaching, the demonstration method has been stressed and it has been found important to have the men and women of the families together in both demonstration and discussions. Farm and home tours to observe good practices have proven very effective. All nutrition has been taught in very simple terms, materials from United States Department of Agriculture and the Colleges of Agriculture and from other sources having suitable material have been adapted for use with low income farm families. Perhaps the outstanding result of increased home production of food by Federal Security Agency families has been improved health. The change in morale as evidenced by the increased participation in community activities goes to show the over-all effect of improved level of living.

Dr. Norman Leon Gold (Food Distribution Administration): Surplus Marketing Administration operation of Food Stamp Program, School Lunch Program, Low Cost Milk Programs, direct purchase and distribution of commodities to needy families; the Cotton Stamp Program; and, with AAA, the use of cotton stamps to reduce cotton acreage and increase home production of food. Little value in teaching unless people can take advantage of education. People in need of better diets must have resources. Currently 4,000,000 people getting about $2.35 per month on Food Stamp Program for food; about 6,000,000 receiving commodities directly through welfare departments in states; 4,750,000 children getting some commodities through school free lunch program—lunches made up in whole or in part of these commodities; about 500,000 people getting milk under low cost milk program; about 281,000 school children getting penny milk. These programs provide a tangible basis for community effort toward education in food values. Can link program to something definite in which whole community can participate. Blue stamps, issued after purchase of orange stamps, insure that surplus foods do not merely supplant others. School lunch programs insure increase in total food consumption, but too many children will get nothing in summer because schools closed. Agriculture has undertaken expansion program toward areas of greatest food needs; some on surplus list are those we do not produce enough of. Need an agricultural program based on nutritional lines; would make sense. Replace export markets. Need 20% more milk; 100% more leafy green and yellow vegetables; 70% more tomatoes and citrus fruits; 15% more butter; 35% more eggs. Food Stamp Program and lunch program concerned with over-all agricultural problem—help both farmer and consumer. Study in Dayton, Ohio, by Bureau of Human Nutrition and Home Economics indicates increase in vitamin content of diet and practically all nutrients; still lack of calcium. Farm program means translating vitamins, etc., into commodities for consumption. Now about to stress increased consumption of fresh vegetables.

Dr. Faith Williams (Department of Labor): Bureau of Labor Statistics in 1918 studied food expenditures in cities throughout the United States. The sample covered families of employed clerical workers and employed wage earner families with at least one child under sixteen. In 1936 made new study of 35 of these same cities including wider family sampling. Increased use of some foods such as fresh fruits and vegetables and milk shows effects of greater availability, campaigns of use of foods; but also indicates strong attachments to special kinds of diets carrying over the whole period to given localities. This latter point important in planning educational programs and use of surpluses, etc.

Miss Frances Stern (Food Clinic of The Boston Dispensary, Boston, Mass.): The Food Clinic came into being about 25 years ago, to serve the needs of the out-patient for scientific food guidance as an aid to successful medical treatment.

The Food Clinic of The Boston Dispensary now has about 7000 visits annually, by 1500 patients. All patients are referred by the staff physicians.

In the Food Clinic the dietician plans the dietary régime on the basis of laboratory and medical findings and recommendations, and on her understanding of the patient and the economic, social, mental, and emotional factors in his life, gained from the medical record and from the nutritional history which she takes in conference with the patient.

Teaching the patient is essential to successful food treatment. To understand why he should adhere faithfully to his diet, the patient must know why certain foods are prescribed for him. So the dietician helps him to understand that foods contain substances or constituents like those of which the body is composed, how these food constituents aid in upbuilding and maintaining health, growth, and vigor, and why the foods in his diet will serve his special needs. Other members of the patient's family are brought into this teaching program, to obtain their understanding and cooperation.

The Food Clinic is constantly developing materials to help interpret these principles of nutrition not only to patients, but to the students who receive instruction in the Food Clinic in the practice of dietetics and to all who teach in the interests of public health. In the Clinic, where the patients represent 30 nationalities, such materials help to overcome difficulties in understanding the spoken word. The exhibit proves to be a most interesting and helpful means of teaching the essentials of nutrition that every one should know.

The book "Applied Dietetics," which describes the principles, procedures, and methods of food treatment in the Food Clinic, with many tables to help in the computation and evaluation of diets, normal and therapeutic, is forthcoming in a new edition.

The Department of Health Education, affiliated with the Food Clinic of The Boston Dispensary, has developed methods and materials for teaching patients while they await treatment. The book, "How to Teach Nutrition to Children," * is the outcome of this work. Its purpose is to teach the food constituents, how they serve body needs, and what their food sources are. Special mention should be made also of a chart "Feed Your Body to Protect Health" which also carries out this philosophy of teaching, and of a color film, "Fun in Food," which is based on the book referred to above. The chart can be obtained from The Food Clinic of The Boston Dispensary, and the film from Films Inc., 330 West 42nd Street, New York City.

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* Pfaffman, Mary, and Stern, Frances. How to teach nutrition to children. New York, Barrows, 1942. 224 p. (Formerly published under title, "Food and your body.")

The Food Clinic extends its teaching program to the community through the food clinic established in the Young Women's Christian Association, the nutrition and health education department in the Burroughs Newsboys Foundation, through special meetings held with mothers in the Dispensary, and to many parts of the world through its publications, students, and visitors.

Miss Grace M. Henderson (Adult Homemaking Education, Cornell University): Have we, who are interested in food habits, responsibility beyond selling an improved diet? May we not actually best achieve that end if we at the same time lead families and groups of families in the further development of the at least equally important ability to think, to plan, to experiment, and to evaluate, in relation to their other needs? We can get people to taste new foods, to exchange recipes, and to want to eat them. We can help homemakers become skillful in preparing them. We can sometimes work with stores and others to make foods available. *But families have to consider food in relation to other wants and must choose among them.* They need to consider costs, relative importance of other needs, and the money and material that is available. Helping them continually to improve this ability and disposition to choose, plan, and decide carefully is our opportunity while working for better health. Family willingness and ability to think independently is basic to a vigorous democracy; as is good food. Many nutritionists are teaching for both purposes. They meet with families and groups of families who discuss not only the relation of food and food elements to health problems, but costs in relation to family incomes and to their other needs. Professional teachers are supplemented by and cooperate with lay leaders in attacking family and community health problems. It takes time, but families recognize the desirability of the slower approach. They want to think, experiment, and evaluate as a family group, in this and other vital daily problems. Good food habits and health then result, and with them, thoughtful management, understanding, ongoing community programs of education and cooperation, and increasingly able local leadership; in short healthful and able democratic communities.

Miss Dorothy Bovee (American Red Cross, Washington, D. C.): *Influence of Education of Food Habits in the Mulberry Area in New York.* Staff Nutritionist at Mulberry Health Center—Little Italy. Selected 135 families at random out of 539; divided into 3 groups: 1) control, 2) to 7 public nurses, 3) special education group. First made survey of entire family situation; special emphasis on food eaten by children (using 5 point rating scale). Did 9 months intensive educational work on group 3. Patient close contact with parents, children; had to establish motivation, etc. Brought out importance of individual teaching, especially for foreign families. At end of 9 months again gave children status (with rating scale) and found considerable improvement in families of group 3. Found it unwise to change diet; better to get people to re-establish old good habits and then help make readjustments in terms of present situation. Reprints of study available at Milbank Memorial Fund.

THE WARTIME RÔLES OF THE NUTRITIONIST

AND

SUPPLEMENTING THE RÔLE OF THE NUTRITIONIST AT THE HOUSEHOLD LEVEL*

April 26, 1942–June 16, 1942

Many leading nutritionists in Washington attended these meetings and participated in the discussion. They commented at first on the background materials and continued with a general discussion. The nutritionists emphasized that their rôle in wartime was very similar to that in peacetime, only more intensified, and that its most important aspect was to provide the scientific information which would be most useful to those working directly with families and their food problems. Too great emphasis on the long-time aspects of the program with only cursory recognition of the war situation was thought likely to detract from the program, as people very easily think of a nutrition program as part of a welfare program that is identified with femininity, passivity, and being on the defensive. The usefulness of the war situation in focusing attention on the importance of good nutrition was brought out with the example of the "Food for Freedom" slogan, which was very effective in giving increased emphasis to progress in food production and nutrition education.

The methods of presenting nutrition information to the public and the rôle of the nutritionist in this activity were discussed. Nutrition interest for many people is synonymous with taking a course, and it is necessary to consider which of the various types of people with some nutrition training can help most in leading such groups. Volunteers, including both those who have had formal training in nutrition and lay people who have taken nutrition courses, can be effectively used only if they also know how to make the teaching and the subject matter alive. An experiment in New York City was described, in which specialists gave the women not only the necessary nutrition information but also the techniques for handling groups and creating the *need* for the information. These women then organized other groups, some in cooperation with schools, and arranged to take care of the young children while the mothers met. Emphasis in these groups was placed on democratic leadership, getting the women to participate actively, and reaching women not otherwise touched by civilian groups.

The motivation for such study groups can easily be found in the present problem of meeting rising prices and the changing food situation and still feeding one's family adequately. This meets the important requirement of combining consumer interests with nutrition education.

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* Background material for these two liaison sessions, held April 26, 1942, and June 16, 1942, were three memoranda, "The Wartime Rôles of the Nutritionist," by Dr. Margaret Mead, "A Definition Study," by Rhoda Métraux, in which definitions of a nutritionist were collected, and "A New York City Experiment in Home Making in Wartime," by Dr. Ruth Benedict. See minutes of Liaison Sessions of the Committee on Food Habits, under same titles.

LOCAL FOOD SUFFICIENCY *

September 26, 1942–November 21, 1942

The first of these two meetings was a discussion of the background material presented by Mr. Frank † and was devoted primarily to the problem of ways in which local food sufficiency for high vitamin vegetables could be developed to meet probable shortages. Mr. David Meeker of the Food Requirements Committee explained that on the average only 10-15% of the vegetable supply is grown in areas adjacent to the cities, and that in addition to the transportation problem there would also be the problems created by serious shortages of labor, both in the production and processing of food. He emphasized the importance of providing labor to maintain essential production in commercial market and truck gardening areas and of finding ways to adjust the diet to maintain health if smaller supplies of certain crops were available.

Some of the difficulties in finding a successful solution were discussed. Victory gardens, or cooperative community gardens, constitute a partial solution to the problem and were thought likely to increase in numbers in 1943. Greatly increased production from local commercial market gardens was not anticipated due to increased labor shortage and, although the use of youth might do much to alleviate the labor shortage, the success of such a program requires the close cooperation of the schools, many of which consider it a threat to the regular educational plan and consequently as something which would have to be incidental. It was emphasized that the people need to be made aware of the seriousness of the situation and to understand the problems of food shortage, of farm labor, of the farmer himself, and of ways of attaining good nutrition, as well as to realize that cooperation is required to feed each community.

At the second meeting, Mr. E. M. Lloyd of the British Food Mission described the British experience in handling local gardening problems. He explained that a great deal of propaganda was used to stimulate the raising of gardens, that the cultivation of vegetables with high vitamin A and C content was stressed, and luxury crops of low nutritional value were reduced. It was shown through demonstration plots that an average plot of ground would supply sufficient vegetables for a family throughout the year, and that was made the goal for all rural families. People paid rent for their plots. England did not find that gardening projects diverted manpower from commercial projects nor that it was impossible to get city people back into gardening habits.

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* See minutes of the Liaison Sessions of the Committee on Food Habits, under same title.

† A memorandum on "Local Food Sufficiency for Improving Nutrition in Wartime," prepared by Mr. L. K. Frank, served as background material for the first meeting, held September 26, 1942.

RATIONING AND MORALE *

November 21, 1942

This session was devoted to a series of papers describing the rationing systems in other countries and a discussion of the possible application and acceptance in this country.

Mr. Sven Dahlman, of the Legation of Sweden, described the Swedish system, in which all the important staple foods except milk, potatoes and other vegetables, and fish are rationed. Milk rationing has been avoided only by diluting the milk 10% and by limiting cheese production to less than a third of the normal. Point rationing has been used for bread and flour products and for meat. Those doing hard labor are given extra rations. Since prices on some of the unrationed foodstuffs have risen considerably, arrangements have been made so that people below a certain income level can buy some of the most important commodities at reduced prices. Very little objection has been made to this system in principal, although many people have been reluctant to accept the price-reduction cards. Democratic cooperation has been used as the basis for the rationing system. It has been well accepted, probably partly due to the Government's efforts to interpret the various regulations and the encroachments on private life and habits, to the educational efforts of cooperating civic organizations and public authorities, and to the fact that the chairman of the Board in each community, upon whom rests much of the responsibility for the actual working of the system, is a member of that community. There is never an advance announcement of rationing, and since in many cases it has been introduced before actual shortage forced it, there has been surprisingly little hoarding.

Mr. E. M. Lloyd, of the British Food Mission, described the British system and emphasized that control must not be merely bureaucratic, but depends upon willing cooperation and the spirit of democratic self-government. At the present time most foods are rationed except for bread and flour, potatoes, carrots and other vegetables, and fish. A value ration is used for meat, that is, the consumer is permitted to spend a certain amount of money weekly for meat; this implies uniform wholesale and retail prices for meat, which is possible only because the Government does all the buying and importing. Point rationing has been applied to a wide range of miscellaneous groceries, including canned meats and fish, and cereals, and also to clothing. Extra allowances of food per meal are given to the factory canteens, which provide the mid-day meal and are compulsory in all factories employing more than 250 workers. Other canteens have been established for heavy workers not in factories, and an additional cheese ration is made available for agricultural and railroad men who could not be served by a canteen. The greatest atten-

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* See minutes of the Liaison Session of the Committee on Food Habits, November 21, 1942, under this title.

tion has been given to the production of milk, which is supplied at half price or free to mothers and children, depending upon income level. Rationing is believed to have contributed to the improvement in the general level of nutrition in England.

Mrs. Frances Rintz, of the Office of Price Administration, reviewed the German rationing system, which differs principally from those in other countries by being part of a total economic plan. It is recognized of importance to morale in any country to guarantee the presence of the ration through planned allocation of food, to make it possible for all holders of coupons to take up their full ration regardless of income through fixed or controlled prices, and to provide for special groups in the population. In Germany a complex system of differential rationing, apparent mainly in the rations of meat, bread, fats, and oils, has been worked out, with nine different categories of people according to age and occupation. Special attempts have been made to compensate for inadequacies in the diet by the differential use of synthetic vitamins or special allotments of foods with high vitamin content. Since every consumer desires to obtain his full share of goods, it is felt that the rationing system has led to a significant leveling out of food consumption among the richer and poorer groups of the population. A device to avoid the black market is the occasional issuance of an extra allotment of a commodity for which other coupons may be exchanged and spent.

The ensuing discussion brought out the importance of recognizing three main problems in regard to rationing: that steps must be taken to insure that the food permitted by the ration is available, that there must be effective demand, i.e., sufficient purchasing power on the part of all members of the population for using their coupons, and that allowances must be made for regional or national differences. In regard to the first, some problems to be met in insuring the ration were the increasing difficulties in production, the growing estimates of non-civilian food requirements, and the waste of food, particularly in restaurants. Rationing is one answer to waste, but may be difficult to introduce at this late date because of the prevalent attitude that "it can't happen here," and also because it is still thought of as a last resort, rather than as a means of putting the full energies of the country into the war effort. Suggestions as to how effective demand might be made certain were 1) to add a subsidy to the basic rationing control in order to increase the purchasing power of the lower income groups, 2) to make coupons valid for only a limited period of time, and 3) to make basic allocation of food supplies like milk. The points system, with advantages to the consumer in terms of freedom of choice and particularly freedom to use any number of stores rather than being tied to one, was discussed. This would mean in the United States a very tight control at the primary distribution point where the coupons would be collected, which is more complex than that in Britain where the government itself sells to the distributor. Since people generally feel they must use all their ration, it was thought that the nutritional level would be raised as a result of rationing foods which should be a part of the diet.

FEEDING LIBERATED COUNTRIES AND NUTRITION EDUCATION *

JANUARY 23, 1943

At this meeting a pattern was developed for presenting information to the American people about feeding liberated countries. The entire program demonstrated 1) how understanding can be developed and interest aroused in the actual engineering problem that is presented by food deficiencies all over Europe, and 2) the steps that can be taken to overcome these deficiencies. It also showed how the material can be integrated into the whole nutrition program so that the American people would learn more about nutrition itself.

According to Mr. L. A. H. Peters, Agricultural Attache of the Netherlands Embassy, information on the situation in Holland is obtained from persons who have escaped from Holland as well as through Nazi-controlled newspapers and radio which, if distorting the data, probably make it look more optimistic. In November 1942, the energy value of the legal food ration per normal consumer per day was 1500 calories, far below the League of Nations standard of 2900 calories. The shortages were greatest in the protective foods, and there was a 76% deficiency in fats and calcium. Silent evidence of this was the 124% increase in deaths due to influenza in 1941 over 1939. In addition, the greater incidence of certain contagious diseases, such as diphtheria and dysentery, was attributed partly to nutritional deficiencies and partly to lack of medical supplies. The need for extensive relief measures in the form of large quantities of meat and eggs, or appropriate substitutes, as well as other foods rich in vitamins and minerals was particularly stressed. Feed and eggs for hatching would also have to be imported in order to rehabilitate domestic production.

Miss Maria Babicka, of the Polish Information Center, reported that the educated and professional classes in Poland are being slowly starved, and the masses are reduced to slavery. Little is known of the food situation in the eastern part of Poland, although the people living there are believed to be in dire straits. In the central region, the aim of the German-controlled economy is to obtain in the shortest possible time the maximum food and economic resources for the German war effort. Official rations amount to only 700-800 calories per day, and yet the people are subjected to the heaviest labor. Horseflesh is a luxury. In such a situation, black markets flourish, but the prices are so exorbitant and wages so low that many cannot patronize them. In the western part of the country, which has been illegally "incorporated" into Germany, the food supplies are allocated for the Poles only after the stores

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* See "Feeding Liberated Countries and Nutrition Education," Journal American Dietetic Association, 19: 259-273, 1943.

Also minutes of the Liaison Session of the Committee on Food Habits, January 23, 1943, under same title.

for the Germans in that region have been adequately supplied. The Jews are subjected to the worst conditions of all as they are restricted to the ghettos where the ration is continually changed and usually reduced, and the black market, where the prices are even higher, is more dangerous because of the strict surveillance and harsher punishment.

It was estimated that Poland would need extensive relief for probably a year after the war, although in certain areas the food-producing potentialities might be fairly good because of the German use of the ground for agriculture.

The North African situation was described by Mr. Milton S. Eisenhower, of the Office of War Information, who reported that the Nazis had taken everything movable from the area, so that food, clothing, and other commodities were so scarce that people could not even use their money. The first thing to be done is to tide over the civilian population with food until the new crop is harvested, and in the meantime help them produce the maximum amount of food themselves by sending necessary fertilizers, machinery repair parts, and fuel for the mechanized farm equipment. Plans should also be laid to give help for the expansion of production as quickly as possible.

As examples of the way in which news about feeding operations could be made both interesting and nutritionally educational, two of the speakers described the present plans for an emergency ration and for longer-time feeding in the liberated countries. Some of the requirements for both are that they be highly nutritious but yet require only commodities available in large amounts, be compact, stable under adverse conditions, and not too hard to eat.

Miss Charlotte Chatfield, formerly of the Bureau of Human Nutrition and Home Economics, United States Department of Agriculture, described the emergency ration, which is planned for use in reoccupied countries behind the lines where there may be complete absence of other foods and very primitive or no cooking facilities. The present plan is to furnish 2,000 calories per day per person at a weight of slightly over one pound. Four rations have been planned thus far, containing as the chief ingredients: 1) a dry soup containing skim milk, peas, seasoning, and brewer's yeast; 2) a reinforced cereal; 3) a biscuit; 4) a peanut butter-soy spread to use on the biscuit. Other plans are to develop some fat to be used as a spread or in the soup, and some source of Vitamin C, either in the form of legumes to be sprouted or concentrates.

Dr. Esther F. Phipard, of the Bureau of Human Nutrition and Home Economics, United States Department of Agriculture, described the problems to be met in planning for longer-time feeding in the liberated countries, namely, estimating carefully the food requirements of each country and planning for the accumulation of food supplies to meet the requirements. Should no food be available in a liberated country, a complete maintenance ration can be built around grain products which are abundant in this country, supplemented by smaller amounts of other types of food. Milk in some form should be sent into every country, and special provision made for children and for pregnant and nursing mothers. Infants in particular should be supplied with a completely adequate food supply as malnutrition at this early age seems to have more disastrous effects later than malnutrition at any other age.

In the short discussion following these two papers, the suggestion was made repeatedly that we need to know the acceptability of these emergency rations to the various nationality groups who may receive them, since possibly a change in the combination of foods, or the form in which they are to be prepared, or in the seasoning, may determine to a great degree their usefulness. It was also suggested that such information could be presented to the American public as a problem solved by ingenuity and nutritional information, and consequently would serve as one indirect method of nutrition education.

In the final paper the vital importance of helping the peasant help himself was emphasized by Mr. George Radin, Lend-Lease Representative of Yugoslavia, who pointed out that after the last war the relief program in Serbia ended when the first crop was harvested. He emphasized that the population of that country preferred to help itself rather than to accept relief; they wanted help to organize their own economy—farm implements, seeds, and domestic animals. Since 76% of the people are farmers and live from agriculture, it will be easier for them to start immediate production of food. The help given them would be handled through cooperative centers, enabling all the inhabitants living in a county, for example, to use the machinery from the center.

Each of the speakers describing the situation in other countries repeatedly stressed the importance of sending not only food for relief, but the means of starting food production in every country, so that each could become self-sufficient in the shortest possible time. The effect on American morale was also emphasized, that whereas after the last war we sent surplus food, after this one we will not have any surplus, and the American people may resist the task of feeding the whole world as too big and impossible. By understanding that it would be only for a limited period of time, they would be enabled to accept the enormous need of the other countries for help from America at the outset of reconstruction and rehabilitation.

PROBLEMS OF FOOD SUPPLY, FOOD HABITS, AND NUTRITION IN CHINA [*]

FEBRUARY 11, 1943

At this conference several papers were given on the present food problems in China, the existing plans for meeting food shortages in other countries after the war, and the ways in which these plans might be adapted in order to give the most effective help possible to China.

Mr. Owen Dawson, Agricultural Attache, State Department, discussed the Chinese food supply. At the present time, due to floods, famines, and distribution problems, outstanding shortages are one million tons each of wheat and rice and 300,000 tons of soy beans. These shortages are not distributed evenly over the whole country, however, and compared with pre-war supplies, which showed some deficiencies also, there is relatively sufficient food in Free China. The difficulties there are primarily problems of distribution which caused the famines in four areas during the past year. There has been some difficulty in collecting enough food for the army and civilian employees. In Occupied China there are great deficiencies due to poor crops and floods, and in addition there is very little organization to meet the problems of collecting, marketing, storage, and distribution in particular. There is little possibility of sending food to China now, but when it can be sent in they will need quantities of wheat, wheat products, soy beans, and rice, and small quantities of dairy products, meats, marine products, and a few concentrated vitamin supplements.

Dr. Gwei-Djen Lu, College of Physicians and Surgeons, Columbia University, discussed the particular problems of each of the three parts of China, starting with the information collected before the war. The West, or Free China, used to be a rice-eating region, but because of the influx of people from many other parts of the country now is a region with mixed food habits. There have been only occasional reports of nutritional conditions from Free China recently, but according to the impression of various medical men there were no serious food deficiencies. It is the most fertile country in China.

In the north, wheat and maize are the staple foods. Millet and kaoliang (sorghum) are also used. Soy bean products are being used throughout the country. There has been much deficiency in Vitamin D and calcium and some proteins. Past findings were that there was severe Vitamin B and B_1 deficiency in the south, evidenced by chronic and acute beriberi. In addition, there were also mild deficiencies in Vitamin A, B complex, and C, although southerners did not get rickets, probably because of the sunshine. There have been several reports since 1937 on Vitamin C deficiency in every part of China.

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[*] See minutes of Conference of Committee on Food Habits, February 11, 1943, under same title.

After 1937, the data obtained from a nation-wide survey of food made by the Extension Division of the Agriculture Department in Nanking was used to calculate the Vitamin B_1 intake. The results of the study showed that beriberi was prevalent in the south where the B_1 intake was below 350 I.U. daily, but did not occur in the north where Vitamin B_1 intake was over this amount from their staple food, rice or wheat. The acute form of the disease beriberi is precipitated also by the climate in the south. People in this area lose the water soluble vitamins from the body more quickly during the hot days.

One of the greatest difficulties in getting sufficient Vitamin B into the diet in the south is that the people cannot eat whole rice. It takes three times as long to cook, does not taste good, causes discomfort, and is incompletely utilized. Grinding is one way to overcome some disadvantages but adults always use rice in grain form. However, a ground rice paste with the vitamins preserved by fractional sterilization, and prepared by adding the juice from cooked greens, was developed for babies who will eat it if they have known nothing else. When a baby is four months old, egg yolk is added to furnish more nutrients, and in some cases cod liver oil, a few drops daily, is supplemented.

An experimental attempt to feed boys coming into the factories from the country districts showed that an adequate diet could be furnished even on the extremely meager money allowance. Rice was the mainstay, and if milled without washing it would contain enough Vitamin B, but had to be used immediately to prevent deterioration. Other food requirements were supplied by providing vegetables, either sprouted or pickled, and proteins from meat, fish, or eggs.

Dr. Lu's suggested solution of the rice problem is that the whole rice with the husk be stored, and partially milled only very shortly before needed. This would mean that all the large feeding places, particularly those controlled by the army, government, schools, and factories, would have to be organized with this plan well understood.

The afternoon session of the meeting was devoted to a discussion of the present plans in this country for emergency and long-term feeding, and the possible usefulness of such foods to the Chinese. Dr. Lu thought that the Chinese would be glad to eat the emergency ration * which is being developed, except for the cheese which not over 20% would enjoy. She suggested that certain foodstuffs needed in Europe not be sent to eastern Asia, where the people could use other foods. Cocoa, for example, would be preferred by the Europeans. Among the products which will be needed in China are rice, wheat, peanuts, soy beans, butter, milk or other animal proteins; e.g., eggs and fish products, which will help to correct the serious Vitamin A and other deficiencies. Vitamin A deficiency occurs at present and even in normal times in almost all areas of the country. Of these needed products, the rice supply in this country is very low at present, while fish meal is used only for fertilizers and the process of making it has not been sufficiently per-

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* See report of the Liaison Session of the Committee on Food Habits, January 23, 1943, "Feeding liberated countries and nutrition education," for description of rations.

fected to furnish it for human consumption. Dr. Lu suggested that soy beans and peanuts be shipped separately because the Chinese have hundreds of uses for them which would not be possible if they were combined. She thought the best way to meet the egg shortage would be to send laying hens for developing the poultry and egg industry. If eggs are not exported after the war from the large producing centers in Occupied China, there may be plenty for home consumption.

Other substitute foods were considered. Bone meal, made from the bone marrow, is used in some combinations in China, and might be a food which would be accumulated in this country as most bone at present goes into animal food or fertilizer. Although millet has better vitamin content than wheat, it was not considered a good alternate. There is not a great deal of it and its use is limited.

There was some debate over whether wheat should be sent as flour, which would be easier than sending it as grain, and as what kind of flour. Since white flour has been sent into parts of China after other famines, it has higher prestige and a better flavor to the people, so that those who have had it prefer no other kind. There is danger that the white flour habit might be fastened upon the Chinese. Enriched flour is hardly the solution because Chinese methods of cooking wheat flour noodles involve discarding the liquid in which they were boiled. Suggestions for meeting this problem were that data on the percentage of people eating wheat should be collected (as is being done) and that the acceptability of whole wheat might be determined by trying it with Chinese groups in this country.

IMPACT OF THE WAR ON LOCAL FOOD HABITS*

March 27, 1943

This meeting was devoted to a series of papers presented by individuals who were in particularly advantageous positions to observe the changes in the food habits of selected groups of the population. Each paper was commented on by Mr. W. M. Drummond, Assistant Washington Representative of the Wartime Prices and Trade Board of Canada.

The reports illustrated clearly the fact that food habits are not a question merely of individual behavior, but respond to the impact of an enormous number of changing situations. Most obvious is the change in the amount of food available. In Detroit, according to Mr. Andrew Brown, of the Division of Services to Labor, Detroit Council of Social Agencies, the supply of vegetables was the same as for last year, but was no longer adequate because of the influx of 350,000 more people. Mrs. Esther Marenholtz, of the Division of Program Surveys, Department of Agriculture, reported that on the West Coast many people had had no fresh meat at all for as much as six weeks and that they had requested that meat be included in the rationed food.

In addition to the change in food supply, there are decreases in food services. In Detroit, 6% of the restaurants were reported to have closed, because of both the manpower shortage and the cuts in food allocations, and at the same time an increase in restaurant eating was anticipated. There was a 10% decrease in retail stores in Detroit, not among those operating on a narrow margin, but supposedly among the many grocers who felt that they could not stand the pressure any longer.

Alterations in the price structure and shifts in the economic level account for some changes. The difference in arrival time in New York and Detroit of an Office of Price Administration telegram freezing prices resulted in a real shortage of snap beans in Detroit, since they could be sold for higher prices in New York, where the market was still open when the wire arrived and the prices were raised before they were frozen. In some areas meat shortages are attributed to the fact that some groups in the lower economic levels have much more purchasing power than previously and can buy meats which they formerly saw purchased only by others, as, for example, in a Virginia county. Dr. Arthur Raper, of the Bureau of Agricultural Economics, United States Department of Agriculture, reported that the lower income tobacco growers there have made more money than ever before, and so bought a beef roast every two or three weeks during the tobacco sale season instead of only once or twice a year.

The attitudes toward the changes taking place will determine whether the changes are likely to become permanent or will be considered only temporary, to be discarded as soon as the war is over. A study in the Chicago area made by Mr. Herbert Passin and Mr. John Bennett, Office of War Information, showed that the reactions of people to rationing, scarcity, and shortages are determined to a great degree by their general attitudes toward the war; those with a midwestern type of isolationism are likely to be against rationing. In many other areas, people are relying on rationing to solve the problems of shortages; they think of it as a means of equal distribution and of insuring enough for all, not as a conservation measure.

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* See minutes of the Liaison Session of the Committee on Food Habits, March 27, 1943, under same title.

Changes in the frames of reference of some people were reported, a shift in prestige from expensive items to those dietetically valuable, and an increased emphasis upon husbands' diets and needs as hard-working men, with differential rationing suggested. On the other hand, the rigidity of thinking in regard to meal patterns was shown by the attitude on the West Coast that "lunch meats" were not a substitute for meat and by the general resistance in the Seattle area to talking about "substitutes." In Seattle, they preferred to think that they were making choices and were confident they could take care of themselves.

A second function of the meeting was to illustrate the interdependence between Canada and the United States, because what is done in one country is interpreted very often on the basis that both countries are alike, with little understanding of the differences. Mr. Drummond pointed out some of the differences in the dietaries of the two countries, such as the greater consumption of potatoes and butter in Canada, due partly to the smaller supply of other vegetables and fats, as well as the differences in attitude toward shortages caused by the war, which had been felt for a longer period of time in Canada, and also cited the greater control over purchasing power in Canada.

The need for a more inclusive plan in regard to food in this country was emphasized. Although rationing may in some cases encourage the purchase of rationed foodstuffs, it cannot be expected to influence the diet of the people unless all essential foods are rationed, nor is this considered at present to be a legitimate purpose. There are many problems not being met by any agency, such as are created by the disappearance of retail stores or restaurants, or by the absence of ice supply for an entire community, or those created by lack of adequate eating facilities in industrial plants. These situations point to the vital need for a coherent program including all aspects of food supply and distribution.

SPECIAL SOCIAL SURVEYS IN GREAT BRITAIN

April 15, 1943

At this conference, Dr. Mark Abrams, who has been connected with the surveys of family consumption and expenditure conducted for the British Ministry of Food, described the development of methods, present procedures, type of results, and their relationship to the government's subsequent food policies and courses of action.

Dr. Abrams first presented some background information essential to the understanding of such survey work in Britain. In the various social surveys carried out during the past few decades it had been found that most members of the working class fell to the poverty level, as defined, for example, by Professor Bowley, at some time or another in their lives. The pattern was regular. A large proportion of working class children were born into poverty; they and their families remained there until the children were old enough (at 13 or 14 years of age) to go out to work. This often brought the adolescents and their parents above the poverty line, and prosperity lasted until the young people married in their early twenties and left home. Their departure once more reduced their parents to poverty, and the prosperity of the newly founded family lasted only until they in turn became parents. This rhythmic pattern means that any policy for dealing with poverty and malnutrition in Britain has to be directed toward specific groups at specific stages in their family life.

Secondly, British economy is a very highly urbanized one and before the war was extremely dependent upon overseas trade for food and textile raw materials. This made it necessary very early in the war to cut down the standard of living in terms of certain foods and clothing by as much as 50%. Some of the more spectacular cuts were in eggs, citrus fruits, meat, and milk. The problem was how to maintain the necessary minimum of health to produce for a war economy that was obviously going to last a long time.

Thirdly, the war has caused extreme dislocation of British family life, as shown by the very high rate of drafting men, the industrial mobilization of women, the evacuation of children to safe areas, and the decentralization of key factories. The latter meant transplanting large numbers of workers and their families, and often the economies of many areas were not geared to bear the increased population. The ordinary routines of family life were severely disrupted.

To help meet some of the resulting problems, a joint survey committee of the Ministries of Health and of Food began work in the last quarter of 1939. It had no survey machinery of its own, but worked through an outside research agency which developed the necessary research techniques for obtaining the appropriate information.

The annual *sample of* 10,000 working class families comprising the sample studied by this committee is picked on a random basis from the electoral registers of Great Britain. In this way a complete cross-section of the population is obtained and the classification into groups and types is done subsequently. If a family has moved since the registers were compiled, the family that has taken its place in the residence is studied. Since practically no housing construction has taken place since the outbreak of the war, there are no new addresses. There are very few refusals to cooperate (3-8%) and in general about 70% of the families are willing to be studied three times at three-month intervals. No compensation for cooperation is given, but after each quarterly survey is completed, a letter is sent by the Ministry of Food, thanking the informant and explaining how her cooperation has helped in the planning of the war effort.

Each investigator studies six families a week. At the beginning and end of this period she weighs all the food stocks in the house, and during the period helps the housewife keep a record of the price, quantity, and weight of all food which comes into the house, whether purchases or gifts. All meals eaten outside the house are recorded, as well as any meals given visitors in the house. The composition of each meal and the members of the family present are also recorded—primarily as a check on the housewife's account of her purchases.

At the end of the week, the investigator has complete information as to the family expenditure on food and its intake of food. It is then possible to classify the family in terms of its nutritional standing. Given the nature of Britain's pre-war imports, some of the main deficiencies to be expected were in vitamins A and C, calcium, and first-class protein.

The results, generally available one month after each survey, are used by the Ministry in planning imports and priorities on imports of certain foods. And similarly, the tabulations are such as to help in adjusting rationing, food prices, food taxes, and money and food subsidies to obtain the best state of health among the people. For example, deficiencies found in specific groups, as in families with many dependents, can be remedied by supplemental factory and school feeding and the subsidized pricing of children's foods; for certain groups. Differential rationing of cheese and other protein foods was indicated to make up for their unsuspected deficiencies. The surveys also show which groups are not using the specially developed sources of vitamins, such as rose-hip syrup, in which their diets are deficient, and then appropriate film, radio, press, school, and factory campaigns are developed.

The meeting closed with a discussion of the difference in the use of research material in Britain and in the United States. Some suggested that the smaller size of the British ministries makes it easier for research documents to reach everyone concerned with policy. It was said that in Britain the basic assumption apparently is that environment, i.e., prices, supplies, etc., is to be manipulated through whatever necessary means so that people get enough food, while in the United States the assumption apparently is that people must make the adjustment.

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The relative effectiveness of a lecture method and a method of group decision for changing food habits. By Kurt Lewin. June 1942. 9 p. Mimeographed.

A group test for determining the anchorage points of food habits. By Kurt Lewin. July 1942. 21 p. Mimeographed.

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* Other available publications include reprints of articles by Margaret Mead, listed as numbers 19-21 and 23-25 under "Bibliography" on page 30 of this report.

† Single copies of available publications may be obtained free of charge by writing to the Committee on Food Habits, National Research Council, 2101 Constitution Avenue, Washington 25, D. C. Prices for additional copies will be quoted upon request.

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BULLETIN
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INADEQUATE DIETS AND NUTRITIONAL DEFICIENCIES IN THE UNITED STATES

THEIR PREVALENCE AND SIGNIFICANCE

REPORT OF THE COMMITTEE ON DIAGNOSIS AND
PATHOLOGY OF NUTRITIONAL DEFICIENCIES,
FOOD AND NUTRITION BOARD

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PREFACE

During the past decade the results of dietary surveys and nutritional appraisal among the population have been reported at irregular intervals in widely scattered journals; hence their full weight in the aggregate has scarcely been considered. For convenient reference but more for provision of proper perspective, it was thought useful to bring together all the available results.

In addition, this review contains a considerable amount of previously unpublished material. Because of lack of uniformity in selection of standards and in presentation, the results of most diet studies as originally recorded could not be compared. For this review several authors at much effort recalculated and reclassified their data on a uniform, authoritative and comparable basis. Here the results appear in this form for the first time. To these authors the Committee on Diagnosis and Pathology of Nutritional Deficiencies expresses its deepest appreciation.

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THE PREVALENCE OF INADEQUATE DIETS AS SHOWN BY SURVEYS

Every nutritional survey in the past decade has revealed that the consumption of diets below the recommended standards is widespread in the United States. In 1933 in New York City, 48 percent of the low-income families canvassed had an average daily caloric intake below that estimated to be the minimum requirement;[1, 2] 26 percent had diets yielding an energy value by approximately 20 percent or more under that level. In the same year a survey of low-income families in Baltimore, Cleveland, Detroit, Pittsburgh, and Syracuse showed that 27 percent of them had an average daily caloric intake lower than the minimum standard;[2, 3] 18 percent had diets with a caloric value approximately 20 percent or more below that level. Two-thirds of all the families surveyed consumed diets at or below the minimum standard level for several protective foods. It is to be noted that the minimum level, whether for energy or protective foods, allowed no margin of safety. Consequently, the proportion of families with unsatisfactory diets was certainly much higher than has been represented.

Among families of employed wage-earners and clerical workers in 43 industrial centers in eight major geographical regions, it was found during 1935 and 1936 that the maximum proportion of white families with good diets in any region was only 21 percent.[4] In the region with the poorest showing, no more than 11 percent of the families had good diets. Between these two, the percentages in other regions were intermediate. Only 11 percent of the colored families had good diets.

In the Committee's interpretation of the rating of diets and the standards upon which it is based (Table 1), anything less than good was considered as not satisfactory; * consequently, the percentage of families with unsatisfactory diets was extremely high. Indeed, by the original rating the proportion of families having diets rated as poor † ranged from 40 percent of the white families in one region, as the least, to 64 percent of the colored families in another region, as the greatest.

---

* According to the system of grading (Table 1) specified in the original paper,[4] fair diets more than met minimum requirements, but were inferior to good diets. Here fair is used in a relative sense. In their interpretation of such a relative scale, persons are apt to attribute a value to a diet which it does not possess on an absolute basis. To many persons fair may appear to have a certain amount of goodness and to be regarded as satisfactory. Rather it expresses here a degree of inferiority. Especially when a diet falls below a critical level, its relative value of fair is less important than that on an absolute basis it is unsatisfactory. It is doubtful that minimum requirements for any extended period would confer protection against deficiency states. Consequently, meeting basic requirements which are inadequate for any prolonged period is no recommendation of goodness. A diet that falls short, even so slightly, and permits development of deficiency states, may be relatively fair but absolutely it is unsafe. According to the standards of the study, the Committee regards fair diets as unsatisfactory.

† Since these diets failed to meet minimum requirements, a level that will not protect for any protracted period, the Committee would regard them as very poor diets.

About half of the families failed to receive recommended levels of vitamin B_1; slightly more than half did not obtain the advised amounts of vitamin C and calcium; while two-thirds fell short of adequate intake of vitamin A.

Investigations[5] conducted in 66 counties in five broad geographic regions during 1936-37 showed that only 35 percent of white farm operators' families in the North and West and 27 percent in the South had diets meeting recommended allowances (Table 1). Thirty-four percent of the families in the North and West and 30 percent in the Southeast had diets rated as fair. About 10 percent of the families in the North and West and 26 percent in the Southeast were receiving diets poor in one or more nutrients. Since diets rated as fair contained less than 50 percent above the estimated minimum requirements, they should in the Committee's opinion be regarded as poor.* Diets rated originally as poor were below the minimum level; therefore, they are actually very poor. If these two inferior grades of diets be designated as unsatisfactory, it is evident that a substantial proportion of the families were subsisting on a frankly unsatisfactory plane. In the North and West, more than one-third of the diets graded as poor were extremely low in calcium and vitamin A; and one-fifth were below standard in ascorbic acid. In the Southeast, one-half of the poorest diets were extremely low in vitamins A and C and one-fourth were low in calcium.

About one-half of the Negro farm families had diets rated as poor, which in the opinion of the Committee, however, were extremely poor. An additional 28 percent had diets graded as fair, which practically were poor. Nearly one-fifth of the poorest diets failed to contain even minimum levels of protein and vitamin B_1; about one-third were short in vitamin A and riboflavin; and almost one-half in calcium and vitamin C. Contrary to what might be expected, it is clear that even among farm families, engaged in production of food and presumably having ready access to it, the proportion that were improperly fed was extraordinarily high.

During the same years (1936-37) a survey of 140 villages and 20 small cities in five regions stretching across the nation showed that the diets of relatively few families met the specifications of recommended allowances.[6] That is a staggering statement. Fifty-two percent of the families in the North and West and 40 percent in the Southeast had diets rated as fair. Twenty-five percent of the families in the North and West and 30 percent in the Southeast had diets rated as poor. Among the Negro families in the Southeast, 24 percent had diets rated as fair and 63 percent had diets rated as poor.[9] According to a more practical appraisal, the two classes of diets rated as fair and poor were really poor and very poor, respectively. When the percentages of these two categories are combined, it is obvious that an appalling proportion of families were receiving what might with considerable understatement be called unsatisfactory diets.

---

* Here diets were originally rated (Table 1) according to four grades: excellent, good, fair, and poor, based as previously upon two standards. Diets superior to the recommended standard and previously designated good were called excellent. As before, diets inferior to the minimum standard were labeled poor. Diets superior to minimum standard by less than 50 percent were called fair; by more than 50 but less than 100 percent, good. Thus, the class previously designated as fair was now divided into two classes, good and fair. For reasons already specified, the Committee would regard any diet originally rated less than good as unsatisfactory; and any originally rated good as not above question, since it is on the borderline. In absolute terms, the Committee would regard the fair diet as poor and the poor diet as very poor.

In the poorest diets of village families, calcium, iron, and vitamins A and C were almost never present in more than meager quantities. Many diets in the Southeast were probably also low in niacin, but unfortunately the level of this nutrient was not estimated.

TABLE 1

RECENT STANDARDS AND SYSTEMS WHICH HAVE BEEN USED IN EVALUATING DIETS

	Daily allowances for a moderately active 70-kilogram man					
	Stiebeling and Phipard * 1939 [4]		Stiebeling, et al. † 1941 [5, 6]		Food and Nutrition Board, National Research Council [7]	Food and Drug Administration [8] Minimum
Nutrient	A	B	C	D		
Protein, Gm.	67	45	75	50	70	...
Calcium, Gm.	0.68	0.45	0.68	0.45	0.8	...
Phosphorus, Gm.	1.32	0.88	1.32	0.88	...	...
Iron, Mg.	15	10	15	10	12	...
Vitamin A, I.U.	6,000	3,000	6,000	3,000	5,000 ‡	4,000
Thiamin, Mg.	1.5 §	0.75 §	2.0	1.0	1.8	1.0
Riboflavin, Mg.	1.8	0.9	1.8	0.9	2.7	2.0
Ascorbic Acid, Mg.	75	37	60	30	75	30

* Diets were graded as follows:

Good—If the uncooked food furnished each nutrient in at least the quantity specified under Column A. Such a diet was characterized as "providing a wide margin of safety over and above average minimum requirements."

Fair—"Diets better in every respect than the specifications for poor diets, but poorer in one or more nutrients than the specifications for good diets." Such a diet was regarded as providing average minimum requirements with a limited margin of safety.

Poor—If the raw food provided less of any one nutrient than the quantity listed under Column B. Such a diet was said to be in need of improvement with respect to one or more nutrients.

† Diets were graded as follows:

Excellent—Diet provides each nutrient in at least the quantity specified under Column C.

Good—Diet provides at least a 50 percent margin beyond the specifications listed for each nutrient under Column D, but less than 100 percent margin in the case of the vitamins.

Fair—Diet meets or exceeds the quantity specified for each nutrient under Column D, but by less than a 50 percent margin with respect to one or more nutrients.

Poor—Diet failed to meet specifications under Column D with respect to one or more nutrients.

‡ Requirements may be less than these amounts if provided as vitamin A, greater if chiefly as the pro-vitamin carotene.

§ Values expressed in original as international units have here been converted to equivalent milligrams.

In these studies [5, 6] the specifications for an optimum diet used as a standard were formulated prior to the recommended schedule of the Food and Nutrition Board of the National Research Council and were not identical with it (Table 1). From re-evaluation [10] of the collected data against the Council's allowances it has since been found that fewer than one-fifth of the families in this country had food supplies in 1936 that met the Council's recommendations with respect to the seven nutrients studied. About one-fourth of the farm families were in this category, but only about one-seventh of the non-farm families. At least 60 percent of the village and city families fell short of the Council's allowances with respect to calcium, thiamin, ascorbic acid, and/or riboflavin, and 30 percent with respect to vitamin A. Even on farms, one-fourth fell short of the recommended dietary goals in calcium and/or vitamin A, and one-half or more with respect to thiamin, riboflavin, and/or ascorbic acid. Because neither food wastes nor nutritive loss in preparation was taken into account, it was acknowledged that all the figures on dietary adequacy as well as those showing the proportion of families meeting the Council's recommendations tend to be optimistic.

Among 538 farm and 299 village families of Vermont visited in 1936, inadequacy in consumption of fruits and vegetables was found to be common; while low intake of protein occurred in families with children.[11]

Of 100 submetropolitan urban families in Central and Western Pennsylvania surveyed in 1935-37, it was found [12] that the following percentages had diets containing the several requisite nutrients in amounts less than those recommended by the National Research Council: riboflavin, 59; calcium, 58; calories, 49; thiamin, 37; vitamin A, 33; protein, 29; iron, 21; and ascorbic acid, 7.

Inquiry into the diets of pupils in Wilkes Barre, Pennsylvania, in 1937 showed [13] that the following percentages of 748 white children, 1 to 12 years old, were receiving amounts of essentials below the Council's suggested levels: riboflavin, 99; calories, 93; calcium, 92; protein, 81; iron, 81; thiamin, 74; ascorbic acid, 71; and vitamin A, 67. Of 39 white adolescents, 13 to 20 years old, the percentages were: calories, 100; protein, 100; calcium, 100; thiamin, 100; riboflavin, 100; iron, 97; ascorbic acid, 95; and vitamin A, 85. Corresponding percentages for 14 colored children, 1 to 12 years old, were: calories, 100; calcium, 100; riboflavin, 100; protein, 92; iron, 92; thiamin, 85; ascorbic acid, 85; and vitamin A, 54.

DIET SURVEYS CONDUCTED IN YEARS 1938-40

In a survey in 1938 of families on relief in Washington, D. C., it was found that the average daily intake of 87 percent of the white families was less than 2,800 calories per consumption unit, a standard little if any in excess of actual needs.[14] The diets of both white and colored families were extremely low in calcium and only slightly better in iron. Diets as low as these in energy value certainly were deficient in most nutrients.

Diet records of elementary school children in a Maine village—76 in autumn, 1938 and 63 in spring, 1939—showed that only one child in seven attained the minimum standard of one good vitamin C food daily.[15] In the autumn only 17 of the 76 children ate any citrus fruit, the best source of vitamin C, during the week of the record. In the spring, half of the children had some citrus fruit; but only 14 of the 63 had it oftener than once or twice in the week.

To obtain adequate amounts of various essential nutrients, certain types of foods must be eaten in sufficient quantities. Although most of the essential nutrients are distributed in nature in many different foods, some are present in appreciable amounts in only a few types of foods, others only in one type of food. Thus, some essentials to be obtained in sufficient quantities must come from two or three types of food, none of which eaten alone in usual quantities supplies the necessary amount. Other essentials are obtained principally from one type of food. Conversely, a type of food may be the almost exclusive source of a necessary nutrient, or the indispensable source of much of an essential nutrient, or the exclusive source of one and the supplementary source of another nutrient. The several types of food necessary to provide all nutrients form the foundation of the dietary structure. They are essential types of foods because each is the main or indispensable source of one or more requisites.

Unless citrus fruits or tomatoes are included in the diet, it is almost impossible to meet the Council's recommended amounts of vitamin C. Enriched or whole-grain bread or a whole-grain cereal is needed to ensure an adequate supply of vitamin B_1. A green or yellow vegetable furnishes a substantial proportion of vitamin A; it also contains some vitamin B_1. An adequate quantity of milk provides most of the calcium; it supplies a substantial proportion of riboflavin; it also furnishes a considerable amount of vitamin A supplementing that from vegetables; and it yields some vitamin B_1. If milk were the sole source of vitamin A in a diet, it would have to be consumed in excessively large quantities to supply the necessary amount of that nutrient. Meat is the main source of niacin; it also provides a considerable supplement of riboflavin; and supplies some vitamin B_1. If it were the sole source of riboflavin in a diet lacking milk, meat would have to be eaten in exceptionally large amounts. A regular and adequate supply of the principal vitamins and minerals is most readily obtained by consumption of these foods in sufficient amount each day. Otherwise, the diet must be specially planned to furnish all the necessary nutrients.

In its report on Recommended Dietary Allowances [7] the National Research Council presented two sample dietary patterns to show the varied ways in which allowances may be met (Table 2). List I contains the commonly available types of food. Other combinations of food expertly planned, as in List II, will also cover the allowances.

Of 3,432 women college students in six institutions in the North Central States [16] canvassed during 1936 to 1940, the following percentages had dietaries containing less than seven servings a week of the respective essential types of foods: whole grain products, 66; citrus fruits, 57; green and yellow vegetables, 40; milk, 29; and meat, 14.

Among 19 rural families in Lancaster County, Pennsylvania, in 1938-1940, it was found [17] that the following percentages of 42 white children, 1 to 12 years old, were eating less than the amounts of the several respective constituents advised by the Board: riboflavin, 81; calcium, 64; calories, 36; thiamin, 36; vitamin A, 33; ascorbic acid, 24; protein, 21; and iron, 17. For 20 white adolescents, 13 to 20 years old, the corresponding percentages were: riboflavin, 90; calcium, 70; vitamin A, 45; thiamin, 45; calories, 30; ascorbic acid, 30; protein, 20; and iron, 20. For 38 white adults the percentages were: riboflavin, 97; calories, 87; thiamin, 84; vitamin A, 37; calcium, 24; iron, 10; protein, 8; and ascorbic acid, 5.

In a survey during 1939-40 of over 2,000 high school pupils of low-income families in New York City, 74 percent of the pupils had a daily caloric intake below their individually calculated energy needs; 21 percent had less than two-thirds of their computed caloric requirements;[18] 44 percent, 64, and 72 percent had less than the Council's recommended daily allowances of protein, iron, and calcium, respectively; 5, 17 (29 percent of the girls), and 28 percent had less than two-thirds of the approved amounts of these respective nutrients.

TABLE 2

SAMPLE DIETARY PATTERNS, PREPARED BY FOOD AND NUTRITION BOARD, NATIONAL RESEARCH COUNCIL,[7] TO SHOW WAYS IN WHICH ALLOWANCES MAY BE MET

LIST I

Milk	1 pint
Egg	1 daily, if possible. (On days not used, beans, peanuts, cheese, or more milk or meat to be used instead)
Meat, fish or fowl	1 or more servings
Potato	1 or more
Vegetables	2 or more servings. One green or yellow
Fruits	2 or more. One citrus fruit or tomato or other good source of vitamin C
Cereals and bread	Whole-grain or enriched

Other foods as needed to complete the meals.

This list is based on the needs of the average adult.

LIST II

Turnip greens	1 cup
Sweet potatoes	3
Peanuts	20 nuts or 2 tablespoons of peanut butter
Beans or cowpeas	1½ oz.
Tomatoes	1 cup
Corn meal	3 oz.
Enriched flour	3 to 4 oz.
Milk (fresh, evaporated or dried)	⅓ qt.
Lean pork	Small serving 3 to 4 times a week

Molasses, fat, etc., to complete the meals.

The percentages of pupils having less than the standard daily amounts of the several vitamins were: 65 for vitamin A, 53 for vitamin B_1, 70 for riboflavin, and 58 for vitamin C. The percentages with a daily intake of less than two-thirds of the recommended amounts of these essentials were: 38 for vitamin A, 14 for vitamin B_1, 25 for riboflavin, and 29 for vitamin C. It should be noted that a daily intake of essential nutrients less than two-thirds of the advocated allowances probably does not meet even minimum requirements which are not regarded as safe levels.

In contrast,[19] among 293 private school pupils the following percentages had less than the recommended levels of the several essentials: calories, 68; calcium, 61; iron, 36; riboflavin, 36; vitamin A, 35; protein, 26; ascorbic acid, 20; and thiamin, 18, respectively. It will be noted that for every essential the percentage of pupils receiving a substandard amount was less, in most instances much less, in this group from high-income families than in the preceding group from low-income families. But even among the group from high-income families, the percentage of pupils with diets that failed to meet accepted standards of adequacy was appreciable.

A survey of dietary records of 1,082 Farm Security Administration families in Louisiana [20] during 1939 and 1940 showed less than 1 percent which could be classified as good, while 52 percent were fair and 47 percent were poor. Of 573 white families, 1 percent had diets classed as good; 69 percent as fair; 30 percent as poor. Among 509 colored families, none had good diets; 32 percent, fair; and 68 percent, poor. By using a modification of the pattern established by the National Research Council, a score card was developed for evaluating the adequacy of the diets. A diet was rated good, fair, or poor, depending on the number of times each of the types of essential foods was served during the week. A poor diet was distinctly deficient in one or more of the food factors necessary for optimum health. It was stated that diets classed as fair might be defined as borderline diets. An active individual eating such a diet would not receive enough of the various essential substances to meet adequately his requirement. It is notable that citrus fruits and tomatoes were served least frequently.

Among 225 private patients in the upper-income levels,[21] surveyed in Philadelphia in 1940, the following percentages had diets containing less than the Board's recommended allowances for respective nutrients: riboflavin, 77; thiamin, 76; calories, 74; calcium, 46; iron, 40; protein, 37; vitamin A, 26; ascorbic acid, 13. Seven percent of the patients consumed less than the Board's prescribed amounts of all eight factors. The following percentages of the patients had less than 50 percent of the Council's recommended levels of the various constituents: riboflavin, 26; thiamin, 13; calcium, 13; calories, 5; vitamin A, 5; ascorbic acid, 4. In the surveyed group were nine physicians whose diets were as bad as those of the other patients.

EVIDENCE FROM DIETARY SURVEYS DURING PAST THREE YEARS

From January, 1939 to August, 1941 the dietary habits of 7,363 children and adolescents from 3,922 families in Chicago were surveyed.[22] They represented different national and racial groups and a wide distribution of economic and social conditions in the city. Seventy-six percent were white; 19 percent, Negro; 5 percent, Mexican.

The diet patterns of 72 percent of the children failed to meet a standard lower than that recommended by the National Research Council. Ninety-three percent of the Mexican children, 89 percent of the Negro, and 67 percent of the white were eating diets inferior to even the low standard.

Dietary inadequacies were least often noted in the protein foods and most often in fruits and vegetables. Regardless of which of several criteria was adopted for determining adequacy, a large proportion of the diets fell below the standard in the latter foods. The percentages of children with diets that included less than the low requirements of the different food groups were: for meat, fish, and eggs, 15; for milk, 37; for fruits and vegetables, including potatoes, 65. Compared with the National Research Council's recommendations, the diets of 73 percent of the white children were below the allowances for fruits and vegetables, and in the poorest areas 98 percent were below this standard (Table 3).

Analysis of records on 110 rural adults in Chatham County, North Carolina, surveyed in 1940-41, revealed a high prevalence of unsatisfactory diets.[23, 24] Almost all persons received less than the recommended daily amounts of the several nutrients: thiamin, 99; riboflavin, 97; vitamin C and calcium, 84; protein, 83; iron, 82; and vitamin A, 70 percent, respectively. Many ate less than half the recommended dietary allowances of the various essentials, as shown by the following percentages; vitamin C, 72; riboflavin, 71; calcium, 34; vitamin A, 27; protein, 10; and iron, 8. A considerable proportion of the persons obtained less than one-quarter of the standard daily amounts of the nutrients: vitamin C, 45; riboflavin, 23; thiamin, 17; vitamin A, 9; calcium, 4; and protein, 1 percent of the subjects, respectively.

TABLE 3

PERCENTAGE OF WHITE CHILDREN FROM RELIEF FAMILIES AND NON-RELIEF FAMILIES IN DIFFERENT TYPES OF COMMUNITY AREAS IN CHICAGO, WHO CONSUMED AMOUNTS OF PROTECTIVE FOODS BELOW THE NATIONAL RESEARCH COUNCIL'S RECOMMENDED ALLOWANCES

		Non-relief				
	Relief (382)	Poor area (122)	Fair area (465)	Fair-good area (381)	Good area (277)	Very good area (565)
Fruits, vegetables	99.7	98.4	78.1	68.0	56.0	39.5
Milk	40.1	35.2	19.8	13.6	12.3	8.0
Meat, fish, poultry, eggs	42.0	14.8	12.5	11.5	10.1	9.5

From a study of families, both white and colored, in a rural community in middle Tennessee in 1941, diet records were obtained on 1,161 persons.[25–27] Of 206 white infants and children from ages 1 to 12 years, the following percentages were receiving less than the recommended daily amounts of the several nutrients: thiamin, 79; calcium, 77; iron, 70; calories, 69; ascorbic acid, 67; protein, 61; riboflavin, 55; and vitamin A, 45. For 115 colored infants and children in the same age group, the percentages receiving daily amounts of the essentials under the approved level were: calcium, 99; calories, 95; thiamin, 93; riboflavin, 91; protein, 87; iron, 83; ascorbic acid, 70; and vitamin A, 51. The percentages of white infants and children eating less than half the advised daily allowances of the various essentials were: calcium, 39; ascorbic acid, 28; thiamin, 23; riboflavin, 21; vitamin A, 18; calories, 12; protein, 12; and iron, 9. Much greater were the percentages of colored infants and children receiving less than half the recommended daily levels, as shown by the following figures: calcium, 70; riboflavin, 52; thiamin, 47; calories, 45; protein, 35; ascorbic acid, 34; vitamin A, 34, and iron, 24.

Of 113 white adolescents from ages 13 to 20, the following percentages were not receiving the suggested daily amounts of the various nutrients: thiamin, 93; calories, 89; calcium, 87; riboflavin, 85; iron, 84; protein, 78; ascorbic acid, 68; and vitamin A, 60. The following proportions of 76 colored adolescents in the same age group were failing to obtain the advocated daily levels of the several constituents: calories, 100; riboflavin, 97; thiamin, 96; protein, 94; calcium, 93; iron, 89; ascorbic acid, 73; and vitamin A, 59 percent, respectively. Receiving less than half the recommended daily allowances of the various essentials were the following percentages of white adolescents: calcium, 43; riboflavin, 41; thiamin, 29; ascorbic acid, 29; vitamin A, 19; iron, 16; protein, 13; and calories, 11. The percentages of colored adolescents eating less than half the standard daily allowances of the respective nutrients were: riboflavin, 62; thiamin, 55; calcium, 45; ascorbic acid, 42; calories, 42; vitamin A, 37; protein, 33; and iron, 32.

Of 457 white adults 21 or more years old, the following percentages were not eating the recommended daily amounts of the respective constituents: thiamin, 94; riboflavin, 91; calories, 82; calcium, 61; iron, 59; ascorbic acid, 52; protein, 51; and vitamin A, 45. For 194 colored adults, the percentages receiving less than the advised daily levels of the nutrients were: riboflavin, 99; thiamin, 98; calories, 95; calcium, 77; protein, 74; iron, 69; ascorbic acid, 62; and vitamin A, 48. Not a few of the white adults were eating less than half the approved daily amounts of the various nutrients, as shown by the following percentages of the persons: riboflavin, 50; thiamin, 31; calcium, 23; ascorbic acid, 21; vitamin A, 15; calories, 12; protein, 7; and iron, 7. Even greater percentages of colored adults were receiving less than half the recommended daily levels: riboflavin, 77; thiamin, 65; calories, 40; calcium, 40; ascorbic acid, 35; vitamin A, 32; protein, 18; and iron, 17.

TABLE 4

PERCENTAGES OF CHILDREN OF NEWPORT, MAINE, AND OF FRESHMAN GIRLS OF UNIVERSITY OF MAINE EATING LESS THAN RECOMMENDED AMOUNTS OF ESSENTIAL FOODS

Subjects	Leafy, green, and yellow vegetables	Citrus fruits and tomatoes	Other fruits and vegetables	Milk	Whole grain cereal and bread	Meat, fish, and poultry
Newport children	93	80	71	71	62	35
College freshman girls.....	44	19	22	39	69	0

Among children of Newport, Maine, in 1940 and 59 University of Maine freshman girls in 1941, the percentages eating the respective essential kinds of foods in amounts below the standards for a good diet [28, 29] are shown in Table 4.

A dietary survey of 1,169 school children in Worcester County, Maryland,[30] in the winter of 1941 revealed that the following percentages were not receiving satisfactory amounts of the various types of food: vegetables other than potato, 81; fruit, 80; cereal or whole grain, 59; two or more cups of milk a day, 59. In contrast, only 3 percent of the children did not obtain sufficient meat.

Only 8 percent of the children had a diet adequate in all five factors studied. Twenty-three percent were totally deficient in one factor; 35 percent in two; 27 percent in three; and 8 percent in four.

In a study of 780 families of Home Demonstration Club members in twenty-seven parishes of Louisiana [31] in March, 1942, 41 percent had diets scored good; 51 percent, fair; 8 percent, poor. The diets were evaluated by comparing the frequency with which the several types of protective foods were served with the schedule formulated by the National Research Council. In such scoring, it was stated, a poor diet was distinctly deficient in one or more of the food factors necessary for optimum health; while a fair diet did not provide enough of the various food factors to meet adequately the requirements. The percentages of families eating less than the recommended amounts of each of the various types of essential foods are shown in Table 5.

The eating habits of 6,708 grade and high school students—5,255 white, 1,453 colored—in Louisiana[32] in 1942 were evaluated as in the preceding study by the dietary pattern recommended by the National Research Council.

TABLE 5

PERCENTAGES OF FAMILIES OF HOME DEMONSTRATION CLUB MEMBERS AND GRADE SCHOOL AND HIGH SCHOOL STUDENTS IN LOUISIANA, EATING LESS THAN RECOMMENDED AMOUNTS OF ESSENTIAL FOODS

Types of essential foods	Home demonstration club members' families (31)	Grade school and high school students (32)	
		White	Colored
Whole grain cereals	86	92	95
Potatoes	54	84	92
Butter	53	66	95
Citrus fruits and tomatoes	50	75	91
Other fruits	45	68	83
Other vegetables	41	76	86
Green or yellow vegetables	34	51	79
Milk	29	56	91
Eggs	28	77	84
Meat	20	16	31

Only 11 percent of the white and 3 percent of the Negro children received a diet adequate in all essential food factors. The diets were fair (borderline) among 60 percent of the white and 35 percent of the Negro students; poor, definitely deficient, in one or more essential nutrients among 29 percent of the white and 62 percent of the Negro children. Diets scored as fair or poor were not regarded as satisfactory. In Table 5 are shown the percentages of students eating less than the recommended amounts of each of the various types of essential foods.

From a survey of 315 colored families in the Harlem district of New York City[33] in 1942 were reported the following percentages on ratings for food habits: excellent, 8; good, 19; fair, 34; and poor, 39. The four ratings were based on the extent to which their food met in kind, amount, and frequency the Council's recommendations. Here again the conventional designations given to the four ratings express relative gradations: hence, the rating of fair, and possibly good, should not be construed as satisfactory. Accordingly, at least 73 percent of the families had unsatisfactory diets.

In 1941-42, the diets of 1,080 workers in the Lockheed Aircraft Corporation at Burbank, California, were analyzed for their content of both protective foods and essential nutrients.[34] Unless expertly planned for special purposes the diet should regularly contain certain types of foods in adequate amounts; otherwise it is almost certain not to provide recommended amounts of the various essentials. These criteria were applied to the data from the dietary survey of the Lockheed Aircraft workers. Only 36 percent of the men had seven or more servings of citrus fruits or tomatoes during a week. It is surprising that 23 percent had no citrus fruit during a week. About 20 percent had four or more slices a day of whole wheat, rye, or dark bread. Only 7 percent ate a whole grain cereal every day; slightly over 50 percent used no whole grain breakfast cereal in a week. Only 11 percent of the men ate regularly vegetables containing vitamin A. Twenty-four percent had them less than three times a week. Sixty-three percent reported an average daily consumption of milk less than the accepted standard; 37 percent had an average of less than one-half the recommended amount; 11 percent did not drink milk. Eighty percent of the men ate meat with recommended frequency; an additional 15 percent had nearly the recommended frequency.

The frequency of diets equal to or slightly below the recommended amounts for these types of food and therefore receiving a satisfactory rating for them was as follows: vegetables, 21; citrus fruits or tomatoes, 36; milk, 51; and lean meat, 95 percent, respectively. Unsatisfactory ratings for amounts of specific foods were given to the following percentages of the diets: vegetables, 56; citrus fruits or tomatoes, 49; milk, 33; and meat, 1.

It is evident that a large proportion of the diets were low in their content of citrus fruits or tomatoes, vegetables, and milk; hence, they would be unsatisfactory in their content of vitamin A, ascorbic acid, riboflavin and calcium. Indeed, among the foods eaten in less than recommended amounts vegetables and citrus fruits were outstanding. Only 2 percent of the men had diets which approximated the recommended dietary pattern. While 11 percent of the men reported marginal diets, 87 percent had diets which were unsatisfactory for one or more food types.

One-fourth to one-third of the men probably had insufficient calories in the two-day period for which the quantitative diet was reported.

For the various nutrients, there was a great difference in the percentage of diets which met the recommended allowances, as shown from study of two-day diets. The allowance for various essentials was met by the following percentages of diets: protein, 85; iron, 78; niacin, 70; vitamin A, 58; thiamin, 54; calcium, 52; ascorbic acid, 33; and riboflavin, 29. Conversely, diets were deficient by more than one-third of the allowance in the following descending order of frequency for specific nutrients: ascorbic acid, 46; riboflavin, 43; calcium, 25; vitamin A, 15; thiamin, 14; niacin, 7; and iron, 4 percent.

It was reported that "only 8 percent of the men had obtained a diet which furnished all nutrients in amounts equal to or greater than the allowances; and not quite 10 percent had diets which furnished 80 to 99 percent of the recommended allowances. Thus, 17 percent of the men had moderately good or excellent diets. The other 83 percent of the men needed some improvement in their diets. Thirty percent of all diets had less than the two-thirds of the allowance for only one nutrient." When the diet was low in only one nutrient, the specific nutrient involved was ascorbic acid in nearly two-thirds and riboflavin in slightly over one-fifth of such diets. In diets below standard in several nutrients, ascorbic acid was low in nearly two-thirds; riboflavin in 84 percent.

The percentages of 562 white children, 1 to 12 years old, in Philadelphia with diets containing less than the advocated levels of the several constituents were found [85] in 1941-42 to be: niacin, 97; calories, 90; calcium, 71; thiamin, 60; protein, 58; iron, 53; riboflavin, 53; ascorbic acid, 52; and vitamin A, 42. Similarly, the percentages of 38 white adolescents, 13-20 years old, were: calcium, 100; calories, 93; niacin, 86; protein, 71; iron, 71; vitamin A, 71; ascorbic acid, 71; thiamin, 64; and riboflavin, 64, respectively.

Upon inquiry into the diets of 56 white persons, 15 years or older, in Wayne County, North Carolina, in the summer of 1942,[24] it was found that most of the individuals had less than the approved daily quanta of the several essential substances: namely, riboflavin, 100; ascorbic acid, 93; thiamin, 91; calcium, 86, iron, 66; vitamin A, 62; and protein, 55 percent of the persons, respectively. Receiving less than half the advocated daily amounts of the various nutrients were the following percentages of persons: riboflavin, 79; ascorbic acid, 77; thiamin, 43; vitamin A, 27; calcium, 25; iron, 5; and protein, 2.

TABLE 6

Percentages of Persons in the United States, Distributed According to Geographical Sections, Who Were Found Not to Eat Protective Foods

Types of essential foods	New England and Middle Atlantic	East Central	West Central	South	Far West
Citrus fruits, tomatoes or greens	46	41	43	53	41
Dairy products	43	31	31	31	28
Leafy and yellow vegetables	28	26	25	21	24
Other vegetables or fruits	8	8	5	12	7
Meat, fish, and poultry	9	12	12	14	14
Whole grain or enriched products	3	4	2	3	3

Of 39 colored persons, the following percentages took less than the advised daily moieties of the several nutrients: riboflavin, 97; ascorbic acid, 92; thiamin, 90; calcium, 82; iron, 79; vitamin A, 72; and protein, 59. Very large percentages of them ate less than half the recommended daily allowances of the various essentials: riboflavin, 82; ascorbic acid, 69; thiamin, 46; vitamin A, 44; calcium, 38; iron, 18; and protein, 10.

A nation-wide canvass in February, 1943, in which one-day diet records were obtained from selective samplings of the population in each of the forty-eight states, showed that the following percentages of persons had none of the respective protective foods:[86] citrus fruits, tomatoes, or salad greens, 45; dairy products, 34; leafy and yellow vegetables, 25; other vegetables or fruit, 8; meat, fish or poultry, 12; whole grain or enriched products, 3. Distributed according to geographical sections, the percentages of persons who did not eat the protective foods are shown in Table 6.

In Tables 7 to 11 are summarized the results from recent surveys, showing the percentages of persons failing to receive the recommended dietary allowances and the extent to which their diets are deficient in the several essentials.

It should be stated that some experts hold that since the recommended dietary allowances presumably represent "optimum" nutrition with a margin of safety, perhaps many persons who do not have the margin of safety are in no way deficient. In brief they object to labeling diets as deficient which fail to meet recommended allowances. This viewpoint raises two questions: At what levels of their constituent nutrients are diets deficient? What are the meaning and validity of the distinction between minimum and optimum levels?

Several opinions may be cited in support and interpretation of optimum levels as criteria. According to one: "Food plays an important part in determining the internal environment, and differences in this environment, many of which may be too small to be measured by present methods, definitely affect the plane on which physical and mental functioning go on. As far as the immediate or long-term well-being of a person can be improved through dietary betterment, that person falls short of being truly well fed." [37]

TABLE 7

PERCENTAGES OF PERSONS WHOSE DIETS CONTAINED LESS THAN SEVEN SERVINGS A WEEK OF THE RESPECTIVE ESSENTIAL TYPES OF FOODS

Types of essential foods	North Central States, Women College students 1936-40 (16)	Newport, Maine, children 1940 (28)	Maine University Freshmen (girls) 1941 (29)	Burbank, California, aircraft workers 1941-42 (34)
Citrus fruits or tomatoes	57	80	19	49
Dairy products	29	71	39	33
Leafy and yellow vegetables	40	93	44	56
Other vegetables	..	71	22	..
Meat	14	35	0	1
Whole grain products	66	62	69	..

Another states: [38] "There is no reason to doubt, and good reason to believe, that the very wide margin of beneficial increase over absolute minimal need is as valid for human beings as for the experimental animals." Still another writes: [39] "If more were known about the actual vitamin requirements there would be no difference between minimum and optimal requirements, because the optimal presumably is the value which will permit no known pathology to develop and which will maintain the stores of the body at a maximum. Anything less than that could be considered insufficient."

Publications of the past two years confirm the view that the recommended allowances of the National Research Council provide ample margins above the actual needs of normal people for energy, protein, and iron. But for the other nutrients, the levels are none too high or not high enough, according to the intimations in the latest review of the subject.[40]

Nevertheless, Tables 8 to 11 present the proportions of families whose diets fail to meet not only the full recommended levels for constituent nutrients but also 75, 50, and 25 percent of these levels. From this scale anyone can take his choice of levels as a standard. The percentages of diets failing to meet the lower levels are slightly less than those falling short of the full allowances, but they are still very considerable.

TABLE 8

PERCENTAGES OF PERSONS WITH INTAKE OF THE RESPECTIVE DIETARY ESSENTIALS AT LESS THAN RECOMMENDED LEVELS

	Wilkes Barre, Pa.[16]			Lancaster Co., Pa.[17]			New York, N. Y.[18, 19]			Wilson Co., Tenn.[25-27]							Philadelphia, Pa.[28]		Wayne Co., N. C.[24]	
Essential nutrients	748 white children 1-12 yrs., 1937	39 white school adolescents 13-20 yrs., 1937	14 colored children 1-12 yrs., 1937	42 white children 1-12 yrs., 1938-40	20 white adolescents 13-20 yrs., 1938-40	38 white adults, 1938-40	2,037 high school pupils 1939-40	293 private high school pupils, 1939-40	Chatham County, North Carolina,[23, 24] 110 white adults, 1940-41	457 white adults, 1941	194 colored adults, 1941	113 white adolescents, 1941	76 colored adolescents, 1941	206 white infants and children, 1941	115 colored infants and children, 1941	Burbank, California,[24] 250 aircraft workers, 1941-42	562 white children 1-12 yrs., 1941-42	38 white school adolescents 13-20 yrs., 1941-42	56 white, 15 yrs. and over, summer, 1942	39 colored, 15 yrs. and over, summer, 1942
Calories	93	100	100	36	30	87	74	68	..	82	95	89	100	69	95	78	90	93	..	..
Protein	81	100	92	21	20	8	44	26	83	51	74	78	94	61	87	15	58	71	55	59
Calcium	92	100	100	64	70	24	72	61	84	61	77	87	93	77	99	48	71	100	86	82
Iron	81	97	92	17	20	10	64	36	82	59	69	84	89	70	83	22	53	71	66	79
Vitamin A	67	85	54	33	45	37	65	35	70	45	48	60	59	45	51	42	42	71	62	72
Thiamin	74	100	85	36	45	84	53	18	99	94	98	93	96	79	93	46	60	64	91	90
Riboflavin	99	100	100	81	90	97	70	36	97	91	99	85	97	55	91	71	53	64	100	97
Niacin	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	30	97	86	..	..
Ascorbic acid	71	95	85	24	30	5	58	20	84	52	62	68	73	67	70	67	52	71	93	92

TABLE 9

Percentages of Persons With Intake of the Respective Dietary Essentials at Less Than 75 Percent of Recommended Levels

Essential nutrients	Wilkes Barre, Pa.[13]			Lancaster Co., Pa.[17]			New York, N. Y.[18, 19]			Wilson Co., Tenn.[22-27]							Philadelphia, Pa.[28]		Wayne Co., N. C.[24]	
	748 white children 1-12 yrs., 1937	39 white school adolescents 13-20 yrs., 1937	14 colored children 1-12 yrs., 1937	42 white children 1-12 yrs., 1938-40	20 white adolescents 13-20 yrs., 1938-40	38 white adults, 1938-40	2,037 high school pupils 1939-40	293 private high school pupils, 1939-40	Chatham County, North Carolina,[20, 24] 110 white adults, 1940-41	457 white adults, 1941	194 colored adults, 1941	113 white adolescents, 1941	76 colored adolescents, 1941	206 white infants and children, 1941	115 colored infants and children, 1941	Burbank, California,[24] 250 aircraft workers, 1941-42	562 white children 1-12 yrs., 1941-42	38 white school adolescents 13-20 yrs., 1941-42	56 white, 15 yrs. and over, summer, 1942	39 colored, 15 yrs. and over, summer, 1942
Calories	67	100	85	7	5	21	33	29	..	50	77	56	89	36	77	38	43	50	..	..
Protein	35	87	54	0	0	0	11	7	42	24	45	42	74	39	66	3	6	21	14	21
Calcium	69	95	100	33	25	13	38	32	63	43	61	65	75	58	90	32	39	71	61	69
Iron	42	90	54	0	0	0	29	12	52	30	44	55	69	44	60	6	10	50	29	46
Vitamin A	48	72	23	10	15	13	47	22	46	32	42	42	47	30	43	22	19	50	43	59
Thiamin	46	87	62	14	0	50	22	4	98	78	91	76	89	51	80	22	23	36	77	82
Riboflavin	95	100	100	55	75	76	36	10	90	75	93	63	86	39	77	51	25	50	95	92
Niacin	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	12	66	71	..	..
Ascorbic acid	51	79	85	7	10	0	36	7	80	38	50	56	55	54	53	54	33	50	86	80

TABLE 10

PERCENTAGES OF PERSONS WITH INTAKE OF THE RESPECTIVE DIETARY ESSENTIALS AT LESS THAN 50 PERCENT OF RECOMMENDED LEVELS

Essential nutrients	Wilkes Barre, Pa.[16]			Lancaster Co., Pa.[17]			New York, N. Y.[18, 19]		Chatham County, North Carolina,[23, 24] 110 white adults, 1940-41	Wilson Co., Tenn.[25-27]						Burbank, California,[24] 250 aircraft workers, 1941-42	Philadelphia, Pa.[28]		Wayne Co., N. C.[24]	
	748 white children 1-12 yrs., 1937	39 white school adolescents 13-20 yrs., 1937	14 colored children 1-12 yrs., 1937	42 white children 1-12 yrs., 1938-40	20 white adolescents 13-20 yrs., 1938-40	38 white adults, 1938-40	2,037 high school pupils 1939-40	293 private high school pupils, 1939-40		457 white adults, 1941	194 colored adults, 1941	113 white adolescents, 1941	76 colored adolescents, 1941	206 white infants and children, 1941	115 colored infants and children, 1941		562 white children 1-12 yrs., 1941-42	38 white school adolescents 13-20 yrs., 1941-42	56 white, 15 yrs. and over, summer, 1942	39 colored, 15 yrs. and over, summer, 1942
Calories	22	64	38	2	0	5	4	4	..	12	40	11	42	12	45	4	4	7	..	..
Protein	6	36	8	0	0	0	1	0	10	7	18	13	33	12	35	0	1	0	2	10
Calcium	35	79	31	5	0	0	9	7	34	23	40	43	45	39	70	11	10	43	25	38
Iron	9	54	24	0	0	0	4	2	8	7	17	16	32	9	24	0	1	0	5	18
Vitamin A	24	49	15	0	0	8	20	8	27	15	32	19	37	18	34	3	7	14	27	44
Thiamin	15	54	23	0	0	0	3	1	74	31	65	29	55	23	47	6	2	7	43	46
Riboflavin	72	100	85	19	20	24	9	2	71	50	77	41	62	21	52	22	.2	21	79	82
Niacin	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	25	43	..	..
Ascorbic acid	27	54	23	2	0	0	15	2	72	21	35	29	42	28	34	33	13	21	77	69

TABLE 11

PERCENTAGES OF PERSONS WITH INTAKE OF THE RESPECTIVE DIETARY ESSENTIALS AT LESS THAN 25 PERCENT OF RECOMMENDED LEVELS

Essential nutrients	Wilkes Barre, Pa.[15]			Lancaster Co., Pa.[17]			New York, N. Y.[18, 19]			Wilson Co., Tenn.[25-27]							Philadelphia, Pa.[28]		Wayne Co., N. C.[34]	
	748 white children 1-12 yrs., 1937	39 white school adolescents 13-20 yrs., 1937	14 colored children 1-12 yrs., 1937	42 white children 1-12 yrs., 1938-40	20 white adolescents 13-20 yrs., 1938-40	38 white adults, 1938-40	2,037 high school pupils 1939-40	293 private high school pupils, 1939-40	Chatham County, North Carolina,[22, 24] 110 white adults, 1940-41	457 white adults, 1941	194 colored adults, 1941	113 white adolescents, 1941	76 colored adolescents, 1941	206 white infants and children, 1941	115 colored infants and children, 1941	Burbank, California,[24] 250 aircraft workers, 1941-42	562 white children 1-12 yrs., 1941-42	38 white school adolescents 13-20 yrs., 1941-42	56 white, 15 yrs. and over, summer, 1942	39 colored, 15 yrs. and over, summer, 1942
Calories	0	5	0	0	0	0	0	0	..	3	12	3	10	5	21	0	0	0	..	..
Protein	0	0	0	0	0	0	0	0	1	0	4	1	4	3	13	0	0	0	0	0
Calcium	7	28	15	0	0	0	1	1	4	3	9	10	15	7	26	0	2	7	0	5
Iron	1	3	0	0	0	0	0	0	0	1	3	3	8	3	7	0	0	0	0	8
Vitamin A	4	18	8	0	0	0	2	1	9	4	17	5	25	5	20	0	0	0	7	21
Thiamin	1	8	0	0	0	0	0	0	17	5	14	3	13	4	6	0	0	0	5	15
Riboflavin	29	54	23	7	5	8	0	0	23	9	32	7	18	6	20	0	0	0	20	39
Niacin	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0	2	0	..	..
Ascorbic acid	7	15	23	0	0	0	2	0	45	5	13	7	27	7	16	8	3	0	52	49

DEFICIENCY STATES: THEIR CAUSES, FORMS, AND DETECTION

All these surveys, without exception, revealed similar results: marked prevalence of dietary inadequacies as judged by recommended standards. The evidence is consistent. From all the reports it is evident that very many persons are not receiving the recommended amounts of dietary essentials. Accordingly, the evidence that such a large proportion of the population is eating unsatisfactory diets points to possible widespread prevalence of deficiency states. Indeed, inasmuch as diet surveys have limitations and other factors besides diet enter into the production of deficiency diseases, it is possible, if not probable, that deficiency states are more prevalent than indicated by results of dietary surveys.

Even when the diet seems to contain sufficient amounts of essentials, its adequacy is often apparent rather than real. Its adequacy is usually estimated from calculated values. It is well known that heat markedly destroys vitamin C, and it has recently been demonstrated that light causes destruction of riboflavin in food. Accordingly, analysis of prepared food shows much less than the estimated amounts of these essentials. Usually in estimates of diets allowance is made for loss of vitamin C by heat, but the deduction is often too small. No allowance is made for the destruction of riboflavin by light. Hence, diets adequate by calculation may really be deficient.

Furthermore, surveys at any one time will show only dietary deficiencies at that period. It is probable that many persons having a good diet during the survey previously had a poor diet. Few persons have had a good diet throughout life. Unless a perfect diet has been eaten regularly, deficiency states will not have been prevented and nutrition will not be perfect. Slight deficiencies are apt to be ignored as if they were without effect. Nor must the diet have been unsatisfactory over the entire past to lead to this undesirable state; it may have been poor for a short time or at intermittent periods. Persons who proudly assert that their diet *is* exemplary seem to overlook their past record until prompting reminds them that their diet has been satisfactory only for the last few years, that it was unsatisfactory for a longer or shorter period in the past. They are apt to live in a false sense of security in the belief that the change to a satisfactory diet immediately and automatically expunged the consequences of their past unfavorable record. Kruse has pointed out that time and degree of deficiency are important in the evolution of deficiency states.[41] Deficiencies occurring periodically or persisting over years produce cumulative effects. Slight deficiencies lead to cumulative effects just as truly as marked deficiencies. Partially, indeed slightly, deficient diets eaten regularly and periodically over many years have their consequences. Such conditions are very common. For these reasons, deficiency states are more prevalent and severe than indicated by dietary survey.

Even when diet actually contains the recommended amounts of essentials for basal needs and the body is functionally sound, deficiency states may still occur. The standards of dietary essentials are average and make no allowance for individual differences and all increased needs. In a review of this topic Jolliffe [42] has pointed out that certain conditions known as conditioning factors raise the requirements for essentials above the basal level. First, sex and age are indices of increased need: the former because of pregnancy and lactation; the latter because of growth. Secondly, physical exertion raises requirements for essentials. When persons with acute pellagra are kept in bed, even though they be given a pellagra-producing diet, their pellagra temporarily disappears. Thirdly, exposure to light has been reported as increasing the need for certain essentials, particularly riboflavin, nicotinic acid, and vitamin A. Fourthly, exposure to toxic substances increases bodily needs for essentials. Alone, any one or all of these several factors do not produce deficiency states but they may exert a determining or occasioning influence.

In setting dietary allowances, the influence of age, sex, pregnancy, lactation, and physical activity is recognized. It is evident that dietary requirements are not constant, fixed, absolute values but are relative to the conditioning factors that increase bodily needs. Often these factors act in combination. Hence, deficiency states may occur on a seemingly adequate diet. Thus, assuming a satisfactory internal mechanism, a deficiency disease may arise from an insufficient intake relative to age, activity, and exposure to light, as well as to other forms of trauma. Of course, if a deficiency state is already present, lowered storage and impaired tissue condition also raise the requirements.

Still other conditioning factors raise bodily requirements for essentials creating a deficiency. For the most part they are diseases, including infections, and therapeutic agents. Differentiation of these conditioning factors from the preceding group is largely artificial. For one thing, they are not regarded as natural events in the sense that disease is not to be accepted as a necessary or normal occurrence. Besides, they are apt to raise the tissue requirements for essentials beyond what food can supply; indeed, in the case of infections, temporarily beyond what the body can utilize. Then too, they are more difficult to control. But they are just as truly conditioning factors as growth, physical exertion, or light. Often all these factors are called the causes of a deficiency state. Accordingly, there are said to be multiple causes of a deficiency disease. More properly, it should be said that there are multiple conditioning factors. They influence the bodily requirements of an essential.

Accordingly, the term deficiency disease should connote a deficiency in the bodily tissue rather than in the diet. Deficiency in the body may arise under many conditions which produce failure in external supply; interference with bodily transport or utilization; destruction or excessive utilization in body, or excessive excretion. It is evident that a bodily deficiency brought about in any of these ways represents a proportionate need. A common cause of bodily deficiency is the inadequacy of the diet to meet even basal needs. But, as Jolliffe [42] emphasizes, conditioning factors likewise exert considerable influence. Like inadequate diet, these conditioning factors may have been operating at many times over the stretch of past years. Few persons have escaped them. Consequently, a high prevalence of deficiency states is to be expected, much higher than indicated by the results of dietary surveys. All in all, it is clear that many factors contribute to the prevalence of deficiency states. And they determine not only the prevalence but also the acuteness and severity of the deficiency states.

All this evidence points with considerable weight to the widespread prevalence of deficiency states. Yet physicians have insisted that, although they have been looking for deficiency diseases, they rarely or never see them. For some time this has seemed to be an outright discrepancy, but a new concept has now resolved and clarified it. By the notions of deficiency diseases which have prevailed, the physicians have been entirely correct in their assertions. But these notions do not cover actual existing conditions. In speaking of deficiency diseases, physicians have been thinking of the severe acute form. Nearly all animal experimentation has aimed at production of this form. Almost all medical literature bears only on the severe acute form. Until recently none other was recognized. But actually there is relatively little of the severe acute form in this country.

Recently, however, Kruse has demonstrated that there is widespread prevalence of deficiency diseases, not in the traditionally severe acute state but in other forms.[41] He has found that they are very prevalent in a chronic form. Following is a summary of his views based upon gross and biomicroscopic examination. In biological behavior the chronic differs from the acute; whereas the acute is rapid, the chronic is slow in development and in response to treatment. Furthermore, both the acute and chronic processes may be of any intensity from mild to marked. Chronic processes of marked intensity are seen quite frequently in the population. In brief, deficiency diseases have been shown to be widespread in previously unrecognized forms: mild acute, mild chronic, and severe chronic. The acute and chronic processes may be present together. Indeed, not infrequently an acute is superimposed on a chronic condition. Each may be in a different stage and of a different intensity. It should be emphasized that this refers to each kind of deficiency disease. Characteristic tissue changes reflecting form, degree, and stage have been demonstrated in each of four deficiency states. So common, so prevalent, so frequently seen are some of these changes, especially their slighter degrees, that they have been regarded as usual or normal. But their specific location, distinctive and characteristic nature, their reversibility, all attest to their pathological identity as deficiency states.

Time is a factor in the evolution of both the acute and chronic forms; but it is particularly important in the development of the chronic process. In man's life, time is measured by age. Accordingly, the prevalence and severity of the chronic processes increase with age. Most of the chronic changes have hitherto been regarded mistakenly as characteristics of senescence. In reality, however, they are deficiencies developing slowly over a lifetime. These chronic processes may be seen beginning in childhood, even in infancy. The lower the economic level, the more frequently, the more severe, and the earlier in life they occur.

A person's nutritional status today depends on the events of all past days. Upon reflection it is clear that few people have had a satisfactory intake or escaped adverse conditioning factors every day of their lives. These lapses are reflected in tissue changes and, until recently, attempts were seldom made to correct them entirely. Indeed, many persons continue on an inadequate diet for years. Hence, the tissues show the cumulative changes of long, slowly developing chronic as well as rapidly progressing acute processes. All points considered, Kruse concludes, it is to be expected that the prevalence of deficiency states is high.

Newly developed methods are available to detect these states.[48] Gross and microscopic examination of specific tissues for characteristic changes, a method both sensitive and comprehensive, reveals all forms, intensities, and stages, including early or slight lesions. Just as the pathologist, having exhaustively examined postmortem tissue within the scope of his unaided vision, extended his range of perception and observation to slighter changes by applying the microscope, so the physician may observe the lesser changes in living tissue through the biomicroscope. Analyses of blood or urine to determine the concentration of a nutritional essential or the body's saturation with it yield another kind of information. Blood values, reflecting the character of recent diet, indicate the condition of intake, transport or bodily stores of essentials. Much macroscopic, microscopic, and biochemical evidence obtained from surveys is now available.

THE PREVALENCE OF DEFICIENCY STATES

Recent estimates of the prevalence of malnutrition have varied so greatly that the Food and Nutrition Board of the National Research Council appointed a subcommittee to evaluate existing evidence on this question. Its report,[44] published in March, 1942, concluded that "some types of malnutrition are strikingly obvious to everyone, some are apparent only to the physician who looks for them and some are vague and elusive even to the careful observer using the most accurate specialized techniques. If the first group alone is counted the prevalence will be recorded as low, almost negligible. If the second group is counted it will be recorded as high. If the third group is included, then the rate will be sufficiently high to occasion genuine concern."

At that time the evidence on the prevalence of malnutrition was treated under three headings: 1) food consumption records or dietary surveys; 2) official death rates and hospital admission figures; and 3) medical assessments of the nutritional status in samples of the population. It was pointed out that these three methods should not be expected to yield identical information. Even when each is as fully developed and as accurately interpreted as possible, the results can only show trends reasonably parallel.

In this review the data will be treated somewhat differently in order to bring the existing evidence on prevalence more into line with the modern concept of malnutrition. Enough time has not yet elapsed to have any considerable volume of data sufficient to classify each specific deficiency into its acute, subacute and chronic forms, each with a subdivision of mild, moderate, or severe, or to indicate whether an acute or subacute has been superimposed on one of the chronic forms. Yet it is probable that in time a chapter on the prevalence of malnutrition will by necessity treat each specific deficiency by recording the prevalence into at least four major subtypes; i.e., mild acute, mild chronic, severe acute, and severe chronic. It is now possible only to record the evidence under the following headings: 1) recorded prevalence of severe acute forms; 2) recorded prevalence from chemical examination; and 3) recorded prevalence of signs, less severe or more chronic than the severe acute form.

The first group represents the severe acute plus the severe acute superimposed on chronic; while the last group represents mild acute and subacute, mild to severe chronic, and mild acute and subacute superimposed on the chronic. The second classification represents recent dietary habits which are reflected in blood and urine chemistry without necessarily indicating the presence or absence of tissue changes.

RECORDED PREVALENCE OF SEVERE ACUTE FORMS

Evidence from Official Mortality Rates. In tracing the average pellagra mortality in a group of Southern States over past years, it has been noted[45] that up to 1928 it climbed progressively, reaching its peak by 1930. During the next two years it showed a fairly rapid decrease, followed by a gradual decline. After the discovery that niacin (nicotinic acid) is therapeutically efficacious for pellagra, the expected further reduction in the mortality rate of the disease had not materialized by 1941. In part this unfulfillment was attributed to the fact that much of the pellagra was chronic and recurrent.

Evidence based on official mortality rates (Table 12) at best can furnish only information on the prevalence of fatal cases of severe acute malnutrition, and of these only those recognized but in whom therapeutic failures resulted. These rates as published, however, do not furnish a reliable index even of deaths from malnutrition. This is due in part to non-recognition of these and of other nutritional factors causing death, in part to mislabeling and in part to the statistical practice of giving precedence to certain diseases as causes of death over others. It would be interesting to know how much malnutrition is concealed in the 370,600 deaths recorded in 1938 under the heading "diseases of the circulatory system" or in the 75,431 deaths entered under its subclassification "diseases of the heart, unspecified," or among the 2,569 listed as due to "alcoholism," or to know how much is masked by the nomenclature of "senility," "cirrhosis of the liver," and "psychoses."

TABLE 12

DEATHS FROM VARIOUS CAUSES IN THE UNITED STATES REGISTRATION AREA, 1933-40

Cause of death	1940	1939	1938	1937	1936	1935	1934	1933
Pellagra	2,123	2,419	3,205	3,258	3,740	3,543	3,602	3,955
Beriberi	63	40	42	21	11	7	5	1
Scurvy	26	29	30	27	33	30	36	28
Rickets	161	143	244	235	270	261	292	339

Another important factor in evaluating this type of evidence is that the morbidity rates for malnutrition are high in proportion to the mortality. For example, Goldberger and his associates estimated on the basis of a survey in 1917 that there were at least 33 cases of pellagra for each death reported. Sebrell has recently pointed out that this figure is too low, for at that time only pellagra with cutaneous manifestations was recognized. A further factor tending to decrease the ratio of mortality to morbidity in recent years is the improvement in methods of care. Independently, both Sydenstricker and Sebrell arrived at an estimate of 100,000 cases of active pellagra in the United States in 1938.

It is therefore the Committee's opinion that the mortality rates published by the bureaus of vital statistics do not indicate the true death rate from classic deficiency diseases. Even the apparent rising incidence in death attributed to beriberi, from 1 in 1933 to 63 in 1940, suggests this; for it is unlikely that there has been a manyfold increase in fatal thiamin deficiency during this period, and the statistical increase must be ascribed to increasing recognition and better diagnosis. It is thus probable that deaths actually due to malnutrition are many times greater than the mortality statistics indicate.

Evidence from Hospital Admission Rates. Pointing out that in a setting of months or years of an inadequate diet, deficiency disease may be precipitated by even minor illness, Goldsmith determined the frequency with which deficiency states were associated with other clinical diseases among 200 ward patients of all ages admitted consecutively to Charity Hospital, New Orleans.[46] Forty percent had evidence which appeared to indicate definite inadequacy of riboflavin, of niacin, or of both vitamins. An additional 27 percent were considered to have probable deficiency. Thus, 67 percent of the patients examined showed clinical manifestations which indicated an insufficient supply of the two vitamins, the prevalence of riboflavin deficiency being greater than that of niacin. Moreover, 25 percent had signs and symptoms suggesting athiaminosis.

The several signs of ariboflavinosis and aniacinosis were noted among the 200 patients with the following frequency: changes in color, texture, and papillae of tongue, 111; thick, pigmented skin over bony prominences, 90; visual disturbances, 80; nasolabial sebaceous plugs, 65; nervousness and irritability, 54; conjunctival congestion, 44; cheilosis, 34; sore mouth and tongue, 25; gross vascularization of cornea, 18; chronic diarrhea, 17; pellagrous dermatitis, 9. Signs of deficiency diseases were present in all persons with hyperthyroidism, cirrhosis of the liver, and chronic alcoholism, and in two-thirds or more of the patients who had infections, diabetes mellitus, carcinoma, and diseases of the gastro-intestinal tract.

Evidence of general prevalence based on hospital record-room figures are subject to the same criticism as the official mortality rates, i.e., incompleteness due to non-recognition, mislabeling and precedence given to certain diseases over others. In addition, two other factors make this index unreliable. The first is that the hospitalized population is not a representative group, for, like persons with the common cold, patients with malnutrition enter the hospital only when sequelae develop; on discharge neither the common cold nor malnutrition but only the sequelae appear as the discharge diagnoses. The second is that certain anatomic lesions of malnutrition may be so prevalent that they are disregarded. This is paralleled by the practice of recording other highly prevalent conditions. For example, in 1938, according to Bellevue Hospital records, dental caries was recorded in only 0.68 percent of its patients, whereas it is common knowledge that the incidence of dental caries in the adult population is near 90 percent.

A recent survey by Krupp[47] of 400 consecutive patients admitted to the clinic wards of Stanford University Hospital disclosed "the incidence of definite vitamin deficiency disease" as 3.1 percent. Adding those showing "possible mild signs of vitamin deficiency" the prevalence would be increased to 7.5 percent. A critical analysis of the criteria used in this study would indicate that they were in the main recording the prevalence of severe acute types of malnutrition as represented by pellagra, beriberi, scurvy and rickets.

RECORDED PREVALENCE FROM CHEMICAL EXAMINATIONS

Reliable data from this type of evidence is available for iron (hemoglobin), protein and ascorbic acid. Data from chemical examination of blood vitamin

A, urinary or blood thiamin, riboflavin and niacin are still in the investigative stage and cannot as yet be used for survey purposes. Evidence of vitamin K deficiency by blood prothrombin estimations involves surveys on special groups such as the newborn or surgical patients which are not generally applicable or significant for population groups.

Iron Deficiency Anemia. Statistics on the prevalence of iron deficiency (hypochromic) anemia in the population of the United States are not nearly as complete as the figures available for the British Isles. All surveys, however, show a notably high prevalence, especially in children and pregnant women of the lower-income groups. In Table 13 are listed results of the more recent surveys, indicating findings of anemia in from 1.5 to 85 percent of children, 1.0 to 30 percent in adult males, as high as 68 percent in adult females and 9 to 72 percent in pregnancy. It is recognized that inadequacy of other nutrients, particularly of the B-complex or even thiamin alone, chronic blood loss, malignant conditions and possibly factors other than an inadequate intake of iron may result in hypochromic anemia. However, in studies of large groups, particularly of school children, it is probable that the prevalence of hypochromic anemia is a reasonably accurate index of a dietary inadequacy in iron.

Vitamin C Undersaturation. Now that reliable methods are available for the determination of ascorbic acid in the blood, reports of the prevalence of vitamin C undersaturation in population groups are appearing with increasing frequency. Plasma levels below 0.6 mg. indicate less than optimal dietary intakes of vitamin C and levels below 0.4 mg. are considered by most students as definitely abnormal. Williams and Wilder [61] have pointed out "that the normal organism in the basal state has remarkably constant levels of the various constituents of the blood, and that these levels are maintained until there is considerable depletion of stores or until there is disturbance of metabolism. Low levels of vitamins in the blood, therefore, may be evidences of severe rather than mild depletion of stores." On the other hand, plasma levels of 0.6 mg. or more can be consistent with the scorbutic state, for after therapy has been instituted the acute anatomical lesions of vitamin C deficiency, though receding, remain for some time; while chronic scorbutic lesions as represented by hypertrophy or atrophy of the gingival papillae will remain for months. It cannot be too strongly emphasized that low values of ascorbic acid always indicate an unsatisfactory vitamin C balance, but do not indicate the presence of anatomical lesions; similarly normal ascorbic acid values do not rule out vitamin C deficiency as the cause of an anatomic lesion, for recent intake may have elevated the blood level without curing the anatomic lesion.

As shown in Table 14 there is evidence of vitamin C depletion (plasma levels below 0.6 mg.) in a large proportion of our population, varying from 5.5 to 85 percent of different groups. Of special significance is the high prevalence in school children. For example, in small Michigan communities, 49.3 percent of 475 children had serum levels of ascorbic acid below 0.5 mg. percent, and in 1,589 white grade school children in Philadelphia 32.3 percent were below 0.55 mg. percent. In New York City public school children of high school age serum ascorbic acid below 0.4 mg. percent was 32.0, and in private school children only 2.9 percent.

TABLE 13

PREVALENCE OF SECONDARY (IRON DEFICIENCY) ANEMIA

Locality	Subjects	Criteria gms. Hb. per 100 cc. blood unless otherwise specified	Percentage deficient	
Ann Arbor	158 pregnant women (urban) [48]	10.0 C.I. 0.9 C. Hb. 26 x 10-12 G	26.6	
New York City...	a) 325 pregnant women, iron therapy [49]	a) R.B.C. 4,000,000	a) 28.0	
	b) 307 pregnant women, no iron therapy [49]	b) Hb. 11.6	b) 72.0	
Oklahoma City ...	1,000 private obstetric patients [50]	a) R.B.C. 3,500,000	a) 16.4	
		b) Hb. 10.2	b) 9.2	
United States	pregnant women (review) [51]	"Iron deficiency anemia"	30.00-60.00	
New York City...	a) 336 private school children [52]	Boys, 13 gm.; girls, 12 gm.	a) 1.5	
	b) 425 public school children [53]	Boys 13 yrs.: 12.8 to 13.5 gm.	b) 3.3	
	c) 138 WPA employes [53]	14.0	c) 34.0	
		12.0	3.6	
	d) 198 nurses [53]	12.0	d) 27.0	
Pennsylvania	428 school children (representative economic section) [54]	11.5	57.0	
		10.0	13.0	
Pennsylvania	2,400 all ages [55]		Male	Female
	preschool	11.5	51.0	56.0
		10.0	±20.0	±20.0
	school	11.5	14.0	26.0
		10.0	5.0	4.0
	adult	11.5	20.0	30.0
		10.0	±15.0	±15.0
Philadelphia	a) 1,589 white 5th grade children [56]	12.0	29.7	
		11.5	13.9	
		11.0	5.1	
	b) 179 Negro 5th grade children [56]	12.0	69.7	
		11.5	47.4	
		11.0	25.2	
New York City...	100 hospital patients (medical) [56]	10.2	23.0	
Florida	620 rural school children (6-10 yrs.) [57]	11.7	85.2	
		9.6	57.2	
		11.7	77.4	
		9.6	33.4	
Tennessee	1,161 all ages, rural male and female, white and Negro [58]	12.5	34.6	
		11.0	8.1	
	a) 206 white children	12.5	47.5	
		11.0	7.7	
	b) 115 Negro children	12.5	74.7	
		11.0	15.6	
	c) 289 white adult males	12.5	5.5	
		11.0	0.7	
	d) 281 white adult females	12.5	28.7	
		11.0	7.4	
	e) 135 Negro adult males	12.5	25.9	
		11.0	2.2	
	f) 135 Negro adult females	12.5	68.8	
		11.0	26.6	
Southern California	1,170 male aircraft workers (94 percent being 19 to 39 yrs.) [59]	12.5	1.03	
		11.0	0.17	
Michigan	549 children in small communities [60]	14.0	39.7	
		10.0	9.0	

TABLE 14

PREVALENCE OF ASCORBIC ACID DEPLETION

Locality	Subjects	Criteria mg. ascorbic acid per 100 cc. serum unless otherwise specified	Percentage deficient	
			Autumn	Spring
Maine	86 school children [62]	0.6	69.0	85.0
		0.4	46.0	63.0
			Summer	Spring
Tennessee	380 "normal" children [63]	0.7	45.0	61.0
Cincinnati	69 orphanage children [64]	0.5	15.9	
		0.25	5.8	
New York City...	a) 342 private school children [52]	0.6	a) 5.5	
		0.4	2.9	
	b) 425 private school children [52]	0.6	b) 49.9	
		0.4	32.0	
	c) 165 WPA employes [52]	0.6	c) 55.2	
		0.4	39.4	
Washington ..... Montana .... Oregon .... Utah	College students [65]	20 mg. daily excretion	30.0-35.0	
Massachusetts ...	College students		70.0	
Rhode Island	College students		85.0	
Tennessee	1,161 all ages, male and female, white and Negro [65]	0.8	45.9	
		0.6	25.6	
		0.3	7.9	
	a) 693 rural white, all ages	0.6	27.0	
		0.4	14.0	
	b) 370 rural colored, all ages	0.6	30.0	
		0.4	16.0	
North Carolina...	218 persons, rural mill community [66]	0.3	61.0	
		0	27.0	
California	70 hospital patients (surgical) [67]	0.5	77.1	
		0.3	56.9	
		0.15	12.9	
New York City...	100 hospital patients (medical) [64]	0.7	33.0	
Chicago	100 hospital patients (unspecified) [68]	0.4	38.0	
		0.3	19.0	
		0.2	3.0	
New York City...	157 hospital patients (medical) [69]	0.4	42.0	
Southern California	1,170 male aircraft workers (94 percent being 19 to 39 years of age) [69]	0.8	70.2	
		0.6	52.4	
		0.2	10.7	
Michigan	475 children in small communities [69]	0.9	76.4	
		0.5	49.3	
		0.1	12.0	
Kansas	78 normal industrial workmen [70]	0.75	84.7	
		0.50	64.1	
		0.25	39.7	
Philadelphia	1,589 white grade school children [35]	0.8	48.9	
		0.55	32.3	
		0.3	16.5	
	179 Negro grade school children [35]	0.8	67.4	
		0.55	46.9	
		0.3	21.2	
Durham, North Carolina	782 young men at National Youth Administration Work Center [71]	0.6	84.9	
		0.3	54.6	
		0	9.5	

Riboflavin. Feder, Lewis, and Alden [72] have recently surveyed the urinary riboflavin levels in 658 persons comprising laboratory workers, hospital and private patients, medical students, and men called for a physical examination by a Draft Board in Atlanta, Georgia, as well as a large number of individuals from the outlying rural area. From reported data they concluded that perhaps 0.8 microgram of riboflavin per milliliter of urine should rightfully be a critical level above which a value would indicate that the person had an adequate riboflavin status and below which the value would show that the person was to be considered deficient. But to avoid a charge of selecting optimum as the critical level, they set 0.3 microgram per milliliter as the arbitrary level and considered a person with a value below it as deficient in riboflavin. On this basis the following percentages of persons were designated deficient in riboflavin: medical students, 25; white draftees, 30; colored draftees, 50; rural dwellers, 65. It was concluded that widespread riboflavin deficiency prevailed in the area.

Serum Proteins. The effects of inadequate protein intake on growth, reproduction, and vigor are well-known phenomena in experimental animals. In man, however, protein deficiency is recognized almost solely by a decrease in the proteins of the blood with the resulting loss of osmotic pressure and the development of edema. The reduction of blood proteins may occur as the result of an inadequate dietary intake but it may occur as a result of the conditioning factors of malabsorption, poor utilization, increased excretion, or physical exertion. The reduction of serum proteins occurs principally in the albumin fraction, the globulin being normal or slightly elevated in uncomplicated cases and reduced only in severe cases. The most common standards used in this country are those of Peters and Eisenman based on the Kjeldahl technic. They are: total proteins, 6.0-8.0; albumin, 4.0-5.5; and globulin, 1.4-3.0 gm. per 100 cc., respectively.

For survey purposes either total protein below 6.0 grams percent or albumin below 4.0 grams percent, more preferably the latter as the albumin fraction is more influenced by dietary factors, may be taken as definitely abnormal. On this basis, surveys of population groups in rural Tennessee and of industrial workers in California, serum albumin below 4.0 grams percent occurred in 1.7 to 21.4 percent of the population groups studied (Table 15). The lowest prevalence was in children with no significant difference found in white and colored. The greatest frequency was found in colored females, being three times the prevalence found in white males or females and almost twice that found in colored males.

MEDICAL ASSESSMENT OF NUTRITIONAL STATUS

Thiamin Deficiency Polyneuropathy. Though criteria have been established for the diagnosis of mild polyneuropathy none of these signs alone can as yet be said to be due only to a deficiency of thiamin. These signs must be interpreted with a knowledge of the history and of other findings both clinical and laboratory. Nutritional surveys have as a rule neglected to record the presence of such signs as absence of ankle and knee jerks, plantar dysesthesia, calf muscle tenderness and impaired vibratory sensation in the toes. In a survey by Borsook, Alpert and Keighley[59] of 1,153 male aircraft workers, 94 percent being 19 to 39 years of age, 16.9 percent had one or more of the following signs: absence of ankle and knee jerks, 0.3; absence of ankle jerk, 1.8; calf muscle tenderness, 0.4; plantar dysesthesia, 14.7; and loss of vibratory sensation in toes to C-128 tuning fork, 0.7 percent, respectively.

Confirmation of the frequency of these findings has been observed by Harris, Weeks and Kinde[60] in 769 Michigan school children. Their findings were as follows: absence of ankle jerks, 4.3; absence of knee jerks, 2.2; calf muscle tenderness, 2.6; plantar dysesthesia, 2.3; and impaired vibratory sensation in the toes to a C-128 tuning fork, 8.3 percent, respectively.

TABLE 15

PREVALENCE OF HYPOPROTEINEMIA

		Percentage deficient	
Locality	Subjects	Criterion total protein below 6.0 gm. percent	Criterion serum albumin below 4.0 gm. percent
Tennessee	1,161 rural, all ages, male and female, white and Negro[58]	2.7	8.0
	206 white children	1.4	1.9
	115 Negro children	5.2	1.7
	289 white adult males	2.0	7.9
	281 white adult females	2.8	7.1
	135 Negro adult males	2.9	12.8
	135 Negro adult females	2.9	21.4
Southern California	195 aircraft workers (94 percent being 19 to 39 years of age)[59]	...	2.6

In surveys it is not possible to categorically state that all these abnormal neurological signs are due only to thiamin deficiency, as other deficiencies and causes other than malnutrition will produce these signs. In this age group—school children and young healthy adults—other causes, such as neurosyphilis, pernicious anemia, and arteriosclerosis, must have been very infrequent.

If these signs in only half the subjects are eventually proven to be the result of a thiamin deficiency, the prevalence of neurologic changes on a thiamin deficiency basis is large enough in school children and in adult males under 40 years of age to cause genuine concern.

Riboflavin Deficiency. Cheilosis, angular stomatitis, characteristic seborrheal skin lesions and significant degrees of superficial corneal vascularity are all signs which have been attributable to riboflavin deficiency. The most frequent of these signs is corneal vascularity which is undoubtedly associated with riboflavin deficiency in many subjects.[73-75] In acute cases this condition can be observed by slit-lamp biomicroscopy to disappear following riboflavin administration, return when riboflavin is withheld and disappear again when treatment is resumed. In this acute type of lesion the ocular symptoms of burning, itching, asthenopia, photophobia and lacrimation are extremely common. Several investigators[52, 53, 58-60, 76] have used corneal vascularity as an index of riboflavin deficiency in surveys of population groups. Its validity for this purpose has been questioned, for many [77-79] consider that it is not yet confirmed that all or nearly all of these vascular changes are due only to riboflavin deficiency or that they are a necessary accompaniment of other undoubted signs of riboflavin deficiency. The consensus of this group at the present time seems to be that one cannot assume that all significant degrees of corneal vascularization are due to riboflavin deficiency. Sandstead,[80] following riboflavin therapy for 60 to 110 days, found no significant change in corneal vascularity which could be ascribed to this therapy. He concludes "at the present time, therefore, it seems doubtful that superficial vascularization of the cornea, as observed in this study and as found in the general population, should be considered a diagnostic sign of riboflavin deficiency."

On the other hand, Tisdall *et al.*[81] found the prevalence of corneal vascularization among apparently healthy young adults in Canada surprisingly high and seeming to vary with the riboflavin-containing foods in the diet. Riboflavin in large dosage for a period of two months decreased vascularization of the cornea in a large percentage of cases and caused marked improvement in disturbing ocular symptoms. Youmans and Patton [82] have observed a considerable number of subjects with mild but definite corneal vascularization not accompanied by ocular symptoms and in whom there was no correlation with dietary intake of riboflavin, other dietary factors or other evidence of deficiency disease. Reexamination of these subjects showed an improvement or disappearance of the vascularization in the winter or spring season compared with the fall, in spite of a lower intake of riboflavin in the former period. It was suggested that factors besides riboflavin are concerned. Youmans and Patton [82] concluded "that corneal vascularization, even of the characteristic type and of definite degree, does not always mean a general riboflavin deficiency." They then point out that under these circumstances the lesion loses some of its value as a diagnostic test of riboflavin deficiency in population groups. But for clinical purposes they point out that significant degrees of corneal vascularity, plus the history and the results of a therapeutic trial, are not only the most helpful and reliable but the simplest and quickest means of detecting mild riboflavin deficiency.

Pertinent to this view is the rôle of conditioning factors. Sandstead [80] points out the possibility of the acute exanthemata playing a rôle in the high prevalence of corneal vascularity. It will be recalled that physical exertion and light have been cited as examples of conditioning factors in relation to intake. The fact that physical exertion may induce nutritional edema is not regarded as impairing the diagnostic sign of edema in that deficiency state. Nor is nutritional edema regarded as being "caused" by exertion. Just as physical exertion may precipitate nutritional edema, and light, trauma, heat, dirt, or filth may induce or intensify pellagrous skin lesions, so corneal vascularity may be conditioned by light.[75, 83, 84] But this does not affect the validity of edema, of the characteristic skin lesion, or of corneal vascularity as diagnostic signs of protein, niacin, or riboflavin deficiency, respectively. Neither does it necessarily question the fundamental relation of protein, niacin, and riboflavin to these respective deficiency states.

Another point should be emphasized. It has been reported that recession of the lesions of chronic ariboflavinosis is very slow and is complete only after a very long period of time.[41] This is likewise true of other deficiency states. Therefore, short periods of therapy without apparent results may lead to erroneous conclusions. In none of the cases where no improvement has been reported was therapy continued more than a few weeks or a few months.

By use of corneal vascularity as a criterion of ariboflavinosis, but with recognition of the possibility that it may give too high a figure, the apparent prevalence of ariboflavinosis (Table 16) in children varies from 2.3 percent in high-income families to 75 percent in low-income families, while in adults its prevalence seems to vary from 20 to 40 percent.

TABLE 16

PREVALENCE OF CORNEAL VASCULARITY (ARIBOFLAVINOSIS)

Locality	Group	Corneal invasion	Percent
New York City...	354 high school students high-income families [52]	Any degree of corneal invasion	2.3
	495 high school students low-income families [52]	Any degree of corneal invasion	75.8
	138 WPA employes [52]	Any degree of corneal invasion	38.4
	198 nurses [53]	Any degree of corneal invasion	47.0
Southern California	1,171 male aircraft workers (94 percent being 19 to 39 years) [59]	"Streamer type"	42.5
Tennessee	110 white—all ages [58]	Significant invasion	20.9
	47 Negro—all ages [58]	Significant invasion	0
Michigan	710 school children [60]	More than three arcades	53.9
Philadelphia	1,960 grade school children [76]	Any degree of corneal invasion	50.3
		Invasion of limbus only	39.3

Vitamin A Deficiency. Xerosis conjunctivae is a lesion characteristic of vitamin A deficiency in animals [85, 86] and one that is reported to respond to vitamin A therapy in man.[87] From this it should not be inferred that all "spots" or elevations appearing on the eyeballs peripheral to the cornea are xerosis conjunctivae. Some are, but others are pterygium, and others scleral deposits of varying composition. The contention of Kruse [87] that xerosis conjunctivae is a manifestation of chronic vitamin A deficiency has been criticized by Berliner [88] who points out that not all the photographs published by Kruse were characteristic of xerosis conjunctivae, that the vitamin A blood levels are not low, and that many of the lesions in question are those usually ascribed to simple senile changes. It should be noted, however, that trained ophthalmologists after gross and slit-lamp examinations frequently disagree on the appropriate anatomic labeling in a high proportion of "spot" cases. The blood level of vitamins does not necessarily reflect the state of the tissues and cannot be used as a criterion for the absence of a deficiency disease, particularly a chronic deficiency anatomically manifest.[89, 90] In this type of malnutrition the blood reflects the recent intake of vitamin A. Also, to designate lesions of the conjunctivae as senile changes with the implication that senility *per se* is responsible for them is unsatisfactory.[41, 91] This merely identifies the condition with a population in which it is most frequently found, but does not explain its etiology. Even in arteriosclerosis, age is not the essential cause. As William Boyd[92] has stated, "The advance in years merely permits some slowly acting cause to produce the effects in the vessels." In discussing the lesions of chronic malnutrition, Kruse states:[41] "Not all elderly persons show the changes. On the other hand, they occur in children. Time, not senility, is the essential point, and time does not start the changes, it is simply a dimension over which they progress. They are specific avitaminoses in a state of chronicity, due usually to respective dietary deficiencies running over a period of years. Their prevalence and severity vary with the number and degree of deficient diets. . . . . Most important of all, they are reversible, yielding slowly but completely to appropriate therapy." This latter point has been partially confirmed by Jolliffe and Stern[93] who observed that of ten subjects given 50,000 units of vitamin A twice daily by mouth for 10 months, seven showed evidence of responding in the manner described by Kruse. It seems therefore that some of these lesions respond to vitamin A therapy. Some may not, but sufficient time has not yet elapsed to decide this point definitely.

Following a twenty-five week period of high intake of carotenoids (200,000 I.U. of vitamin A as carotene) and a ten week period on 10,000 units of carotene, Getz[93a] has subsisted during the past one and a half years on a diet providing less than 500 I.U. vitamin A daily. At intervals during the entire period of deprivation his conjunctivae were observed with the biomicroscope by several observers; his visual adaptation was tested and his plasma vitamin A concentration was determined. The first change noted during the period of vitamin A deficiency was the appearance of conjunctival changes described by Kruse. Several months later some visual dysadaptation developed. The conjunctival changes were first seen in the third month on the low vitamin A diet, progressing and becoming grossly visible; dysadaptation began in the seventh month; and scaliness on the elbows was observed in the eleventh month. But the level of plasma vitamin A, reaching 180 I.U. per 100 ml. during the preliminary period of high vitamin A intake, never did fall below 93 I.U. during the deprivation period. Not only were his vitamin A stores presumably well stocked at the beginning of the deprivation period, but also conditioning factors during the period were in operation only at a minimum. So far as is known, this is the first attempted and reported instance of experimentally induced conjunctival changes in a person as a result of vitamin A deprivation.

On the basis of "gross" spots the prevalence (Table 17) varies from 7 to 60 percent of the population groups studied, while biomicroscopic changes occur in 50 to 99 percent of all subjects. The prevalence of gross spots is higher in males than in females, in colored than in whites, and in older than in the young.

Vitamin D Deficiency. With the development of knowledge of the cause and prevention of rickets, the prevalence of severe rickets has been reduced greatly in recent years. Twenty years ago, except for regions blessed with more than average sunshine, the prevalence of clinically detectable rickets in infants was estimated by Hess [94] at about 75 percent. Present figures indicate that the prevalence of active and healed clinical rickets is approximately 20 percent among children of preschool age. This figure varies greatly from community to community, depending on urbanization, age, season of the year, race, and the practice of preventive treatment.[95] In Newark, New Jersey, Levy and Silver [96] studied, in the spring of 1937, 100 consecutive infants less than 9 months of age and found clinical evidence of rickets in 37 percent.

TABLE 17

PREVALENCE OF CONJUNCTIVAL CHANGES (AVITAMINOSIS A)

Locality	Group	Criteria	Percent
New York City...	494 high school students from low-income families [52]	Gross spots	7.7
		Biomicroscopic changes	86.6
	143 WPA employes [52]	Gross spots	45.5
		Biomicroscopic changes	99.3
	198 nurses [58]	Gross spots	34.0
Southern California	1,172 male aircraft workers (94 percent being 19-39 years) [59]	Gross spots	47.6
		Biomicroscopic changes	96.6
Michigan	710 school children [60]	Opacity	2.5
		Significant biomicroscopic changes	48.2
New York City...	549 psychiatric patients [69]	Gross spots	60.0
Philadelphia	1,239 grade school children, Part I [76]	Gross spots in characteristic location	8.15
	473 grade school children, Part II [76]	Gross spots in characteristic location	7.39
		Elevated spots in noncharacteristic locations, exclusively	17.25
		Combination of characteristic and noncharacteristic spots occurring simultaneously	2.60
		Biomicroscopic changes:	
		Right temporal region	88.6
		Right nasal region	94.9
		Left nasal region	96.6
		Left temporal region	90.0

In North Dakota the state health department reported in 1937 a study of 5,227 preschool children in whom by clinical methods active or healed rickets was found in approximately 20 percent. In 1941 Rhoads and her co-workers [97] reported a study of 233 children at 2 years of age who had received 110 to

1,500 International Units of vitamin D daily for the previous 22 months of life; active rickets was found in 7.7 percent and healed rickets in an additional 6 percent. The prevalence of rickets in 487 autopsied children between 3 and 19 months, dying in a hospital, was found by Follis, Jackson and Park[98] at 48.4 percent.

Niacin Deficiency. With a single exception, evidence of this deficiency has been based on the severe acute lingual manifestations. It is obvious that both the acute severe form as manifested by a scarlet red glossitis, and the chronic form as represented by complete papillary atrophy, represent end results that are preceded by changes representing deviations from normal up to these recognized end stages. In the acute form hyperemia and hypertrophy of the fungiform papillae impart first a stippled and later a strawberry aspect before the complete scarlet red glossitis is evident. In the chronic form the stages are hyperemia associated with loss of substance as manifested by fissures, crevices and areas of progressive lowering of the papillae until a completely bald tongue is produced. With these changes as criteria, and their detection by the biomicroscope, all 49 subjects in a study[99] showed some abnormal lingual changes. Upon examination of 198 nurses of New York City, 20 percent were found to have subacute changes characteristic of niacin deficiency.[53]

Ascorbic Acid Deficiency. As with niacin deficiency, anatomical evidence of ascorbic acid deficiency has been based on the severe acute gingival lesions. It is also obvious that the severe acute form must be preceded by gingival changes of a degree less than gingivae, consisting of bags of blood which almost completely hide the teeth. In the development of this acute process the first stage consists of capillary engorgement of the interdental papillae and later of the marginal gingivae. As this microscopic lesion advances it can then be seen grossly as a serrated red line marking the interdental papillae and later the marginal gingivae. Then as the lesion progresses the gums become swollen, until eventually the typical scorbutic gums are seen. The chronic form may start as the acute, but somewhere in its development, probably because of the presence of dietary vitamin C but in amounts insufficient to cure completely, atrophy begins as evidenced by pitting on the interdental papillae. It finally leads to gum retraction with formation of calculi between the gums and the teeth, then superimposed infection and so on *ad infinitum* to the end stage of chronic scurvy as represented by complete retraction of the gums, exposing the alveolar surfaces of the teeth, alveolar loosening, infection and extrusion of the teeth. In 49 subjects examined in a study,[100] all showed some degree of these deviations from perfection. In a later study[53] on 198 nurses of New York City acute or subacute changes were observed in 56 percent. The prevalence of undiagnosed scurvy in 487 autopsied children between 3 and 10 months, dying in a hospital, was found by Follis, Jackson and Park[98] at 11.7 percent.

DEFICIENCY STATES VERY PREVALENT IN THE NATION

All the evidence is in agreement that deficiency states are common among the population of the United States. Most of them are not the severe acute type.

Rather, they are less intense in degree and very much slower in their course. Predominantly the deficiency states here are mild, moderate or severe chronic forms. Because of their slow gradual development, their presence is commonly unsuspected. In frequency and severity they increase with age and with lowered economic level. As yet optimum nutrition throughout the nation has not been achieved; on the contrary, deficiency states are present on a large scale.

SIGNIFICANCE OF DEFICIENCY STATES AND OPTIMUM NUTRITION

The serious health handicaps resulting from the florid forms of the deficiency diseases are too well known to require review.[95, 101, 102] Although the severe acute types, with their obvious clinical manifestations, are seen in many parts of the world, relatively few such cases (although perhaps significant numbers) occur regularly in the United States.[44, 47, 103–105] Instead, most of the deficiency states in this country are milder in degree and chronic in type. These various forms constitute a wide zone between obvious deficiency disease and optimum nutritional state. The evidence on the relation of deficiency states in that zone to health is not nearly so clear and has led to some differences in conclusions.[41, 44, 70, 106, 107] Most of the controversy arises out of the confusion of definition, but some of it is based on the type of evidence and its interpretation.

Much of the scientific work in support of the importance of optimum nutrition to health loses its strength if the latter term is defined in the narrow sense as "absence of obvious disease," but becomes distinctly significant if one recognizes health as having more positive attributes. In this latter sense, health has quantitative characteristics involving efficiency, reserves, and the capacity not only to avoid disease but to attain maximum inherited potentialities. This point of view is the basis of preventive medicine and modern public health practice. It is with this definition in mind that the following evidence should be considered.[108–112]

So many factors other than food can enter to influence health during the course of studies on human beings that the full significance of the relation of food to well-being is most easily shown by the use of experimental animals. There are obvious advantages in making observations on a species kept under well-controlled conditions which can be varied at will and can be continued through a generation or several generations if desired. Furthermore, since recession of lesions in chronic deficiency states occurs slowly and requires a long period of therapy, many studies in man on the relation of nutrition to health must necessarily be of long term. Here the use of experimental animals in orientative investigations offers a real economy in time. By this procedure of experimentally searching out the significant data, the subsequent studies on humans becomes less arduous and more straightforward.

Sherman and colleagues [113–114] have shown by a series of carefully planned and executed experiments, extending over a period of years, that diets adequate for the rearing of 50 generations of apparently normal rats can be improved with betterment to the animals. These benefits are made evident by increased growth and efficiency, decreased death rate and increased vitality at all ages. Also, the better-nourished animals not only live longer on the average, but most important of all, the period of prime of life is distinctly increased. These conclusions are based on data of unquestionable statistical significance. More detailed experiments [115-118] reveal that several chemical factors, i.e., vitamin A, calcium, riboflavin, etc., contribute to this improved health record and that up to four times the adequate quantities of these substances led to increased benefits.

Waterman and Ammerman [119] have likewise shown that increased thiamin beyond that amount judged as distinctly adequate will yield improved growth in rats. The farmer has known for years that there was a difference between "just adequate" and optimum feeding. An increased biological efficiency reflected in superior production of eggs, milk, wool, and meat, material results which can be evaluated in dollars, makes a convincing demonstration of the profitableness of better feeding.[120] On purely biological grounds, one would expect analogous benefits to man as measured in better health performance.

McCarrison,[121, 122] struck by the contrast of the well-developed, healthy appearance of the people of northern India compared to the poor physique, low power of endurance and resistance to disease of those races in the eastern and southern parts of the country, undertook a study of the cause of this difference. After considering other factors, such as race, heredity, climate, and endemic disease, he concluded that the nature of the diet was likely the most important factor. To confirm this conclusion experimentally, he raised identical groups of rats on diets representative of the various regions, and he found the same great contrast in growth, development, and well-being of the animals as was observed among the people.

More recently Radhakrishna Rao [123] has shown that monkeys maintained on diets based largely on milled rice and containing supplementary foods in small quantities, similar in composition to those consumed by the poor rice-eaters in India, show the same poor development and occurrence of gastro-intestinal, skin, eye, and mouth lesions as the people in this region.

While these animal studies are strongly suggestive, they are not necessarily proof that man will or does react in a like manner. Orr and Gilks [124] conducted a study to test this point. These investigators compared the physique and health of two African tribes living side by side, alike in most respects except dietary habits. The Masai are pastoral people and consume quantities of milk and meat; while the Kikuyus live for the most part on cereals with some tubers and legumes. The latter tribe is greatly inferior in physical development. The Masai men are on the average three inches taller and 23 pounds heavier, and the Masai women, three inches taller and 27 pounds heavier than the Kikuyu men and women. There was a similar striking difference in the prevalence of chronic respiratory disease, parasite infestation, and general health records. Added evidence that these differences were due to nutrition was indicated by the improvements resulting from changes made in the dietary of the Kikuyu.

EFFECTS OF PROPER DIET ON GROWTH AND DEVELOPMENT

Corry Mann [125] also reports observations from an English institution for boys which bear on this point. One group of boys, six to 11 years old, were maintained on their regular diet, which was well-planned and judged to be good; while other groups received various supplementary foods. The most striking difference observed over a three-year period was between the control group and those receiving an extra pint of milk daily. During the first year the former group gained on the average of 3.85 pounds and 1.84 inches, while those receiving the extra milk gained on the average of 6.98 pounds and 2.63 inches. Orr [126] and Leighton and McKinlay [127] demonstrated the same point on even larger groups. Similar gains in growth and improvement in general health records have been reported both in this country and England as a result of the supplementary feeding through school lunches.[128, 129]

The high percentage of men rejected from the Army because of inferior development and related causes has been distressing to those interested in public health.[130] It is unfortunate that time and facilities have not allowed for better study of the problem in this country. An important experiment in this connection was conducted in England.[131] A group of several hundred young recruits rejected because of under-development and other defects usually considered as due to malnourishment were placed in a camp under optimum conditions of nutrition, exercise, and rest. After several months of such treatment, 87 percent of a group of 834 passed the physical tests which they had previously failed.

Added indirect evidence comes from a recent study [132] of 78,000 Toronto school children which confirms the results obtained many times previously [133, 134] that environmental factors affect height and weight. In this analysis striking differences have been found between the height and weight of children from low-income families and those from higher-income groups. In the Toronto study the percentages of male children under average height in various groups classified according to the occupation of the father were: 29.9, laborers; 24.5, factory operators; 19.8, clerical workers; 18.9, commercial workers; 17.2, owners and managers; and 13.2, professional workers, Thirty-three percent of boys from families on relief were under average height against 22 percent of those not on relief. Only 12.2 percent of those boys attending 10 schools located in prosperous districts were under average height compared with 31.3 percent of those attending 10 schools located in poor districts. Corresponding differences were also found for girls. It is not implied that stature is the only or the most crucial measure of well-being. Nor is it certain that the difference in the quality of nutrition is solely responsible, because differences in sanitation and rest habits also exist between these two groups. However, sound consideration of all the facts certainly implicates nutrition as the most likely cause of this stature effect.

EFFECT OF PRENATAL DIET ON CHILD-BEARING

Ebbs, Tisdall and Scott [135] have investigated the relation between prenatal diet and subsequent obstetrical history of 400 women from a low-income group in Toronto. One group found to be on a poor diet was left as a control. A second group on a poor diet was supplied supplementary food during the final trimester of pregnancy, and a third group found to have a relatively good diet was given education in the best use of food. The past obstetrical history, the various complications of pregnancy, the obstetrician's general rating, ease of labor and birth, breast feeding, response of the child to feeding and infections during the first six months of life, and other factors were measured or evaluated.

They summarize their findings and conclusions thus: "During the whole course of pregnancy, the mothers on a good or supplemented diet enjoyed better health, had fewer complications and proved to be better obstetrical risks than those left on poor prenatal diets. The incidence of miscarriage, still births and premature births in the women on poor diets was much increased. The incidence of illness in the babies up to the age of six months and the number of deaths resulting from these illnesses were many times greater in the poor-diet group. While it is recognized that there are other important factors in the successful outcome of pregnancy, this study suggests that the nutrition of the mothers during the prenatal period influences to a considerable degree the whole course of the pregnancy, and, in addition, directly affects the health of the child during the first six months of life." While more cases are desirable and statistical treatment important, this study presents a strong argument for the importance of optimum nutrition in prenatal care.

Another study along this line has been reported by a Committee of the Peoples League of Health in Great Britain.[186] On the basis of a preliminary survey, a supplement containing those minerals and vitamins found most likely to be short in the diet was given to 1,530 primiparas, while 1,512 continued their regular diet without supplement. The complications of pregnancy, pre-eclampsia and toxemia were statistically less in the supplemented group. The incidence of premature births was also reduced. No differences in birth weight, sepsis after child birth, or character and duration of labor was noted.

Effect of Avitaminoses on Well-Being and Efficiency

The recent, well-controlled human experimental studies at the Mayo Clinic [187] add much to our knowledge of the symptoms and handicaps of early mild thiamin deficiency. Subjects kept on diets as adequate in thiamin as many American diets soon developed evidence of fatigue, irritability, muscular tenderness, and mental confusion. These conditions were paralleled by a definite decrease in efficiency in the relatively simple operations about the household. Although these symptoms and discomforts are admittedly not specific to thiamin deficiency, there seems no doubt in this case that thiamin deficiency is the cause. The symptoms were rapidly alleviated in those who received thiamin but continued to progress in those getting the placebo.

There are a number of mild symptoms and lesions of rather vague origin which occur quite commonly in the general population and which, although not particularly serious, are uncomfortable and distracting and must have a cause. Among these are soreness of the mouth and tongue with change in the papillae; swollen and bleeding gums; mild conjunctivitis with lacrimation; burning and itching of the eyes. These are seen in certain deficiency states. The mouth and tongue lesions of niacin deficiency, the gum lesions of ascorbic acid deficiency, and the eye lesions of ariboflavinosis are examples. Recent efforts [99, 100, 138-140] to observe more closely the changes in these tissues, especially in connection with specific therapy, indicate that many of these cases are due to deficiencies. Conditioning factors in relation to intake undoubtedly may also be instrumental in inducing these lesions and symptoms.

There is a great need for well-controlled studies on the relation of nutritive state to physical and mental efficiency, especially in mild deficiencies. The magnitude of the problem, plus the need for more objective methods have been deterring factors. Several recent attempts in this direction have been reported.

Keys and Henschel [141] have studied the effects of the addition of large daily supplements of thiamin, riboflavin, nicotinic acid, pyridoxine, pantothenic acid, and ascorbic acid to the regular U. S. Army garrison rations on the muscular ability, endurance, resistance to fatigue, recovery from exertion, and certain physiological mechanisms of a group of trained recruits expending 3,700-4,200 calories per day. Test periods of 4-6 weeks, alternating the supplements and placebos, were used. No improvements in performance were observed, which would appear to indicate that healthy young men on an approved ration calculated to contain 1.7 mg. thiamin, 2.4 mg. riboflavin, and 70 mg. ascorbic acid are not demonstrably benefited by a supplement of vitamins B complex and C over a relatively short period of time.

Foltz, Ivy, and Barborka [142] likewise found no influence on recovery from fatigue or increase in muscular efficiency by parenteral injections of vitamin concentrates in persons already on an adequate diet. These studies were interpreted as showing that supplementing an already adequate diet with vitamin B-complex for several weeks has no influence on work output, recovery, or other manifestations of physical exertion. It has been suggested that it would be desirable to have longer experimental periods in such studies.

Simonson, Enzer, Baer, and Braun [143] have reported a study on the influence of vitamin B-complex surplus on the capacity for muscular and mental work. Measurements on endurance in dynamic and static work, recovery of work capacity and pulse rate, maximum muscular force, fatigue of voluntary effort, maximum frequency of finger movements, errors in calculation tests, and fusion frequency of flicker were made on 12 apparently normal subjects who received over a 6-12 week period daily supplements of 6 mg. thiamin; 80 mg. nicotinamide; and 8 mg. riboflavin. The performance of this group was compared with a control group of 11 similar subjects. No effects of the supplementary vitamins were observed in the muscular work tests. However, there was observed an increase in the fusion frequency of flicker in 8 of 12 of the supplement group after 3 weeks, as compared with no change in the placebo group. This increased ability to detect flicker frequency, reputedly "a measure of central nervous system fatigue," dropped to the initial values 4-6 weeks after cessation of the vitamin intake.

When men are restricted to a diet deficient in the vitamin B-complex, the effects on physical performance are striking. Egana, *et al.*[144] have made observations and measurements on 7 healthy physicians who subsisted on a diet deficient in B-complex for 4 weeks and then had small added amounts of brewers' yeast for 2 weeks. Mild and vague symptoms of pain, fatigue, and loss of ambition were observed, and there was a moderate deterioration in the subjects' physical fitness for exhausting exercises and particularly poor recuperative powers between repeated periods of exhausting exercise on a treadmill. The same changes were rapidly reversed upon the addition of yeast to the diet.

Even more striking were the effects of vitamin B-complex deficiency in men doing daily hard work. A similar study by Johnson, *et al.*[145] from the same laboratory on 10 subjects engaged in hard physical labor showed that under these conditions symptoms of muscular and joint soreness, fatigue, and physical deterioration were more rapidly produced, being noticed after one week on the deficient diet; and while the addition of thiamin improved these conditions, especially muscular symptoms, the addition of yeast was necessary for full recovery.

In trained subjects restricted to diets containing about one-third of recommended daily amounts of the vitamin B-complex, Barborka, Foltz, and Ivy [146] found that subjective symptoms of easy fatigue, irritability, lack of pep, anorexia, and increased leg pain appeared during work periods and work output decreased. All the symptoms completely disappeared and work output returned to normal or better within a few days following supplementation with vitamin B-complex.

It seems probable from the above reports and other evidence that there is a level of nourishment which, while it is not low enough to lead to easily recognized symptoms of deficiency disease, nevertheless does lead to decreased physical and mental efficiency. However, it is evident that additional well-controlled experiments on subjects whose initial nutritional status is known, who can be maintained for long periods on various levels of intake of the several factors (vitamins, proteins, etc.) and whose performance is measured in an objective manner, are needed before satisfactory conclusions can be made regarding nutritional status and physical and mental efficiency.

Diet and Dental Caries

The cause and prevention of dental caries is one of the most puzzling and difficult problems in public health today. There are several schools of thought on the subject, each with its pet theory. The literature is extensive, confusing and controversial.[147-149] It seems evident that the problem is more complex than generally realized, that many factors are probably involved, and that the solution is not in sight.

However, in all this confusion, there are certain observations and conclusions related to nutrition that seem worthy of emphasis. There is sufficient work of good caliber to indicate that attention to diet can not only decrease the prevalence of caries, but give some protection against the further development of that already present.[147, 150-154] Also, it is equally evident that malocclusion, uncleanliness, bacteria, too many sweets and unknown factors are involved in the process.[147-149] Unfortunately, a satisfactory experimental animal has not been found for this type of work.

Somewhat over a decade ago it was shown by Mellanby [155] that dogs reared on diets faulty in calcium and phosphorus, as well as vitamin A and/or D, lead to poorly calcified (hypoplastic) and otherwise malformed teeth and supporting structures, factors said to be important in the caries problem. Subsequent well-controlled studies by the same author in a London institution for children [154, 156] clearly showed that the prevalence of hypoplastic teeth and caries could be greatly decreased by the addition of the above factors. Confirmatory observations have been reported by several others. Boyd and Drain [152, 153] and Howe and White,[150, 151] and others have shown that the increased use of meat, milk, fruit and vegetables in the diet is followed by a reduction in occurrence and severity of caries. The formation of a hard, secondary dentin as a protective reaction at the base of developing caries as a result of better nutrition is reported by several investigators.[150, 151]

One of the most interesting facts about dental caries is the geographic distribution of high and low prevalence groups.[157] In central Alaska, certain island groups and other small areas of the world usually remote from modern influence, the prevalence of dental caries is conspicuously low; while in most other areas it is 95 to 98 percent.[158, 159] When members of these low-caries groups come in contact with world commerce, the prevalence of dental caries increases rapidly. This has been observed repeatedly. The report of King [160] gives a full bibliography of these observations, as well as details of his own studies in the Island of Lewis in the Outer Hebrides off the Scottish Coast. The prevalence of dental caries in a large group living on the coast near an active port was about like that observed in London, e.g., 98 percent; while inland where modern influence has not reached, the frequency was on the average about 40 percent. The other most conspicuous difference in these two areas was a change of diet from the natural foods of high nutritive quality of the interior to that containing highly-processed flours, sugar, etc.

Thus, there is much presumptive evidence indicating that nutrition plays a part in the dental caries. The question is how? Bunting and his associates [147, 161] contend from their evidence that it is the presence of high carbohydrate in the diet with subsequent bacterial action. But the evidence indicates in addition that positive nutritive qualities of the diet also are involved.

NUTRITIONAL STATUS IN RELATION TO SUSCEPTIBILITY AND RESISTANCE TO INFECTIONS

Considering the variety of infectious agents studied, the different routes and extent of exposure employed, the many types, combinations, and degrees of deficiencies involved, and many other factors which are sure to enter any observations on the relation of nutrition to infection, it is not surprising that the literature on this subject appears inconsistent, confusing, and difficult to evaluate.[162–164] All infectious processes are not the same. Each shows specific characteristics. Nor do the various deficiencies affect the body in the same way. The relation of nutrition to infection is not one problem but many, and considerable more work of a well-controlled nature is necessary before a fully adequate answer can be given to this relation. However, there are certain points which seem reasonably clear, and several results which should be mentioned.

The relation of diet to infection is not to be compared with the dramatic effects of successful vaccines, serums, or drugs; but rather with other environmental factors, such as general physical condition, sanitation, personal hygiene, and rest. There is no doubt that severe degrees of malnourishment in experimental animals, like fatigue and low body temperature, lead to an increased incidence of spontaneous infection and to increased susceptibility to certain induced infections.[164] This is particularly true of vitamin A deficiency, but also to some degree with other deficiencies. The high morbidity and mortality rates from infections among those with severe deficiencies indicate that this is also true for the human being.

In Experimental Animals. There is some evidence that mild degrees of deficiencies also lower resistance. Webster and Prichett[165] have found a definite difference in resistance to mouse typhoid, bichloride of mercury intoxication and botulinus toxin between two groups of mice, both of which were thought to be normal and adequately nourished as shown by satisfactory growth and procreative powers. Wooley and Sebrell[166] have shown that mice kept on diets inadequate in riboflavin or thiamin are more susceptible to fatal infections with pneumococcus type I inoculated by the intranasal route than were mice fed on diets containing enough of these vitamins for good growth. King and Menten,[167] and King and Sigal[168] have shown that guinea pigs receiving inadequate amounts of ascorbic acid succumb to smaller doses of diphtheria toxin than those receiving liberal amounts of ascorbic acid. Rinehart, *et al.*[169] have found that the heart lesions due to β-streptococcus infection in guinea pigs are greatly intensified by superimposed chronic scurvy. A lowered tissue resistance to infection has been observed in several of the deficiencies;[170-172] for example, in the skin lesions of riboflavin deficiency, the mouth lesions of black tongue and pellagra, and in the lesions of the eye in vitamin A deficiency.

Badger and Masunaga[173] report a lowered resistance to rat leprosy in thiamin deficiency. Sabin and Duffy[174] have shown that the constitutional barrier to the entrance (muscular route) of the neurotropic virus (vesicular stomatitis virus) which normally develops in young mice by the sixth week is delayed by the malnourishment. This effect was shown by general undernourishment, i.e., low calories; also by B-complex and vitamin E deficiency. However, once the barrier had developed, neither thiamin, riboflavin, nor vitamin E deficiency had an effect. Riboflavin deficiency,[175] even in a relatively early state, greatly lowers the resistance of rats to endemic typhus, thereby resulting in a fatal disease. Animals severely deficient in vitamin A are as resistant as normal animals. No other virus or rickettsial disease has as yet been found to react this way, so this seems to be an example of a specific and extremely severe lowering of resistance. In general, malnourishment has shown quite the opposite effect in relation to virus infections.[164] Recently Foster, *et al.*[176] and Rasmussen, *et al.*[177] have reported that well nourished mice are more susceptible to murine poliomyelitis than those deficient in thiamin or calories. Perhaps this is another confirmation of the close symbiotic relationship of the viruses to man.

Trager[178] reports a decreased resistance of chickens and ducks to *Plasmo-*

dium lophurae as a result of mild biotin deficiency. Some degree of specificity of biotin is shown by the fact that general debility due to other deficiencies does not give the effect.

From numerous animal experiments [179–184] it seems well established that diet is an important factor affecting the reaction of the host to the establishment and maintenance of hookworm and other such parasitic infestations. It has been shown in dogs and rats that injury to the host by the worm may not only be reduced (i.e., anemia) but that in many cases the infestation may be eliminated by improvement in diet alone. This supports the repeated observations and contentions [184–185] of many that poor nutrition is a very important conditioning factor in the epidemiology of hookworm and related parasites in man.

In Man. Such direct evidence on the relation of mild deficiency states to resistance to infection in man is lacking, but there are several bits of evidence which should be considered. The incidence and duration of illness in a low-income group as measured by loss of time from work and hospital days have been reported as being significantly higher in a low-income than in a higher-income group.[186] Harper, *et al.*[187] have reported a statistically significant decrease in loss of time due to minor illnesses of a group of 70 R.A.F. cadets as a result of supplementing their regular diet with vitamins A, C, and D. The prevalence of infectious diseases among the poorly-nourished populations of the world is striking and cannot be explained by sanitation, personal hygiene, and insect carriers.[164] Orr and Gilks [124] in the studies previously mentioned found that 37 percent of the tribe living on a poor diet suffered from chronic respiratory infections; while in the better-nourished tribe living under the same climatic conditions, this type of illness was found in only about 4 percent. Tuberculosis, tropical ulcers and intestinal parasites were also low in the better-nourished group. The tribe habitually eating a poor diet showed a marked drop in morbidity and mortality rate within a year after their dietary had been improved. Like observations have been reported from India and other parts of the world.

Without questioning the presence of infection and climate as factors in rheumatic fever, there is considerable evidence that an additional factor such as poor nutrition, found to be more prevalent in low-income groups, is involved.[164, 169, 188] The importance of good nutrition to resistance and recuperative power is recognized by most physicians and surgeons who give attention to this point, as well as rest, as part of general treatment. Also, in their experience, all other factors being equal, the poorly-nourished patients constitute the greatest risks.

APPLICATION OF THE SIGNIFICANCE OF OPTIMUM NUTRITION

In considering the application of existing knowledge on the significance of optimum nutrition for health and well-being, it is pertinent to mention that it is difficult to sell the idea prophylaxis, especially if its benefits lack drama, or if they appear slowly over a long period of time. Then too, the early evidence for the importance of a biological science to preventive medicine is usually founded on animal experiments. Later, statistical measurements may be necessary to show conclusively the benefits to man. Also, such human studies require such a large program that progress is slow. To the average mind neither animal experiment nor statistics has a very strong emotional or personal appeal, and slow acceptance of this type of evidence is to be expected. But, in addition, there is a mistake which appears to be more or less prevalent and which indicates an insufficient understanding of this type of evidence but is serious because it has, without a doubt, retarded the acceptance of the newer knowledge of nutrition in some quarters. This is the mistake of supposing that an unsound procedure is involved in carrying over the findings from one species to another. Whereas, the fact is that the application of animal experiments to human problems in nutrition depends upon the same assumptions that have been used with such success in the developments of physiology and bacteriology, and which are the foundation on which the practice of medicine is built.

On the other hand, some persons may expect a good diet or improvement of nutritional status by therapy to confer absolute protection against all infectious and metabolic diseases. In any relationship between nutritional status and infection, it is evident that nutrition is only one consideration, that such factors as exposure and virulence are not to be disregarded. Hence, whatever protection is conferred by favorable nutritional status may be expected to be in terms of probability rather than certainty.[189]

There is no denying that there have been some premature or exaggerated claims for the benefits of optimum as compared with just adequate nutrition, that the literature contains reports of many poorly-conducted experiments and interpolations, and that there are those who make a living by exploitation. But these human failings should not produce a reaction which retards the acceptance of the real merits of the science. Much more knowledge of the relation of nutrition to health is desirable and is being uncovered at a rapid rate. Nevertheless, keeping in mind the view that buoyant health, not just passable health, is the objective of modern health philosophy and practice, the evidence now available, incomplete as it may seem, leads to but one conclusion. It is that there is a real difference, as measured in terms of growth, development, and general health record between optimum and just adequate nutrition; and that every practical effort should be made to apply this knowledge in the interest of human welfare.

SUMMARY AND CONCLUSIONS

All the evidence from numerous surveys over the past ten years to the present among persons of all ages in many localities is without exception in complete agreement that inadequate diets are widespread in the nation. Although an appreciable percentage of the diets failing to meet the Council's recommended dietary allowances were more than 50 percent deficient in amounts of the several essential nutrients, most of the diets were less than 50 percent deficient. Accordingly, there is widespread prevalence of moderately deficient diets.

It has long been recognized that other circumstances besides deficient diet impair nutrition. Certain so-called conditioning factors, such as physical exertion, light, trauma of several kinds, and disease, raise the requirements for essentials. Therefore, adequate intake is an individual matter related to the conditioning factors in operation. If these factors are sufficiently severe, even optimum intake may not completely protect against their force during the period of maximum operation. It is evident that many factors affect nutritional status.

But evidence that deficient diet or conditioning factors are in operation at some particular point of time gives only a slight and incomplete conception of the full scope of their influence and effects. The frequency and duration of their operation is extremely important. Thus time, which for persons is age, is a significant factor. Few people eat an adequate diet every day during their lifetime. Rather, there are numerous or protracted periods when the diet is faulty. Similarly, few people escape the operation of conditioning factors at frequent or lengthy periods in their life. The repeated or protracted operation of faulty diet or various conditioning factors slowly leads to cumulative effects in deficiency states.

All the data from numerous surveys with new methods among persons of all ages in many regions are entirely in accord in showing that deficiency states are rife throughout the nation. Relatively few are the traditional severe, acute types. Most are milder in intensity and gradual in their course. Predominantly they are subacute or chronic states: some marked, but very many mild or moderate.

From this evidence it is clear that there is both a preventive and corrective problem. On the preventive side, it is evident that production of sufficient food should be maintained and that more effective distribution of proper food is needed. For the latter, it would seem advisable to give further consideration to the program of judicious enrichment of appropriate foods since that would add much to the guarantee of successful nutrition. It is also evident that diet education must be intensified and extended to the utmost, and raised to new heights of effectiveness.

On the corrective side, there is need for detection and therapeutic treatment of deficiency states among the population. For this project it is necessary to disseminate the new diagnostic methods among the medical and public health professions. Foremost among the steps in this direction would be: (1) preparation of a handbook on methods of detecting deficiency states; (2) establishment of training centers for instruction in the medical aspects of nutrition, especially diagnosis of the deficiency states; and (3) introduction of adequate courses on nutrition, particularly its clinical aspects, into medical schools.

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BULLETIN
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ENRICHMENT OF FLOUR AND BREAD

A HISTORY OF THE MOVEMENT

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With the Aid of the Committee on Cereals
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PREFACE

Enriched flour and enriched bread are to be found today in almost every grocery store and bakery and in most households. Thus millions of persons know that these products represent customary brands of white flour and white bread with added vitamins and iron. A growing number have learned from the American Red Cross classes or from other teachers of nutrition how white flour and white bread are made more wholesome by enrichment. Many have heard that this procedure for improving bread and flour is endorsed by prominent physicians and scientific advisers of the government. Many persons suppose that this enrichment program is enforced by national regulation and its continuance is insured as a permanent policy. They have heard correctly that standards for enrichment have been set up by the government, and this has led them to believe that all bread and all flour must meet these standards, which is not the case.

From its inception in 1941 until January 1943, enrichment was entirely voluntary on the part of the miller and baker except in two states which in 1942 adopted laws requiring it. Yet on this voluntary basis, it was extended to cover 75 to 80 percent of the nation's bread and family flour. Since early in 1943, a war regulation requires enrichment of bread but only for the duration; there is no federal regulation requiring enrichment of flour. Except in a total of six states, all of them in the South, which have now enacted laws about it, enrichment of both bread and flour after the war will depend wholly on the free will support of individual firms in the two industries, unless further action is taken.

The motive behind the enrichment program has been the nutritional improvement of certain basic foods at their sources through the commercial channels. It has seemed possible by this means to secure results promptly. The health of the population can be improved by education, but by itself education represents a long and difficult process. For immediate results in nutrition, as in sanitation, a degree of direct action is required. In this respect, enrichment of a staple food like bread is a public health measure analogous to correction of an unsafe water supply; once this is accomplished and the matter placed in competent hands; the benefits of good water are permanently available to all without the necessity for each householder to boil his own drinking water daily.

In its introductory stages, the voluntary cooperation of millers and bakers has been indispensable and the extent of it has been both surprising and gratifying. But can we afford to rely on it alone in the future? As the war comes to an end, we shall enter on an era of more or less economic disturbance and it may well be that severe competition will arise in some of our staple food industries. Since enrichment adds somewhat to the costs of the millers and bakers, some will be tempted to drop it, as indeed some have all along refused to adopt it unless required by law to do so. The far-sighted elements of the industries cannot compel their more shortsighted competitors to continue it. For these reasons, the majority of both industries are ready for compulsory legislation of a reasonable and uniform character. Are representatives of nutritional science and public health leaders ready to accord them this support?

Largely because ninety percent of the nation's bakery bread is consumed within the state in which it is produced, bread is little subject to federal law. It is therefore much more feasible for the several states to act effectively by legislative means than for the national government to do so. This is less true of flour, of which a large part is shipped in interstate commerce, but obviously flour and bakery bread should be treated similarly since the two foods are more or less interchangeable in family use, choice turning to one or the other according to convenience or tradition. Therefore, while the Federal Food, Drug, and Cosmetic Act was invoked to furnish a standard of degree and kind of enrichment permissible for flour and bread, the question of whether enrichment shall be required must be submited to the states.

After more than three years of experience with nation-wide, though not universal, enrichment of bread and flour, it seems the time to raise this question with the people who are responsible for public health and for control of food quality in each of the states. It is the purpose of this bulletin to review this experience, and to set forth the merits of enrichment as well as its shortcomings under voluntary action. Many intricate problems of technical, legal, commercial, and nutritional nature have arisen during the inauguration of the program. These are set forth in response to enquiries and requests from leaders in nutrition who are interested in the introduction of enrichment legislation in their state legislatures, most of which will be in session in January 1945.

It is particularly important if legislation is enacted by the states that it be uniform in its provisions. Otherwise interstate commerce in the affected commodities will be hampered and the universal practice of enrichment will be rendered difficult.

An abbreviated statement entitled "The Facts About Enrichment of Flour and Bread" has been prepared in a form suitable for those who can spare time for only a cursory study of the subject. The present bulletin is intended for state leaders who will be faced with a great variety of questions if state legislation is proposed. It is therefore indexed for convenient reference. Copies of either publication may be secured from the National Research Council, 2101 Constitution Avenue, Washington 25, D. C.

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CHAPTER I

LAUNCHING THE MOVEMENT

In the past several years it has become possible to produce several nutrients in very inexpensive forms. As demand increases, industry undoubtedly will be able to produce them at progressively decreasing cost. These advances, owing largely to the chemists, have placed in the hands of authorities in public health a powerful means for improving the quality of common foods. The Council on Foods and Nutrition of the American Medical Association provided early leadership in the movement to make proper use of vitamins and minerals to improve the nutritive quality of staple foods. Minerals were readily available for such purposes, and several vitamins in concentrated forms or as the pure products of chemical synthesis were entering the market. They were mainly in the drug trade; their use in foods was limited to a few specialty products, and the guiding motive for additions of vitamins to such products often seemed to be for advertising purposes. Exceptions were the addition of vitamin D to milk and of iodine to table salt. Both of these procedures received endorsement by the Council.

This Council, then known as the Committee on Foods, in a meeting held March 12, 1936,[1] discussed fortified foods. While no definition of such foods was attempted, it was understood "that in general a fortified food was one in which the percentage of mineral elements or the unitage of vitamins has been made significantly beyond that of the same food as it exists in nature. This enhancement of the vitamin (or inorganic salt) content is brought about by the addition of a concentrate or rich source of the material or the actual salts or vitamins themselves." The committee at earlier meetings had approved addition of vitamin D to milk and of iodine to table salt. It now announced a policy as follows:

> "If in exceptional cases a general need for vitamin (or inorganic salt) intake above that afforded by the usual mixed diet of common foods is indicated, the Council shall require (a) acceptable and convincing evidence that there is a need for enhanced amounts of vitamins (or inorganic salts) in the general food supply, and (b) that the food vehicles proposed for the distribution of such vitamins (or inorganic salts) are suitable and appropriate."

The next important action was taken in December 1938, by a joint committee of the Council on Foods and Nutrition and of the Council on Pharmacy and Chemistry, both of the American Medical Association. Favorable consideration then was given to use of vitamins in certain staple foods including flour. Indiscriminate fortification of foods with either vitamins or minerals was considerd to be undesirable, but a standardized fortification of certain cheaper foods which were widely used was regarded as deserving of encouragement.

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[1] Committee on Foods, A. M. A.: Jour. Am. Med. Assoc. 107:39 (July 4) 1936.

On the basis of the report received from the cooperative committee of the two Councils, the Council on Foods and Nutrition then proceeded to take action. It appointed one of its members, Dr. Cowgill, to prepare for publication a Council report on the evidence indicating a need for restoring vitamin B_1 to the American diet.[2] It accepted, and with minor reservations it adopted (March 18, 1939), a resolution which the cooperative committee had submitted. This appeared in final form as follows.[3]

Fortification of Foods with Vitamins and Minerals

> "The Council on Foods and Nutrition desires to encourage the restorative addition of vitamins or minerals or other dietary essentials, in such amounts as will raise the content of vitamin or mineral or other dietary essential of general purpose foods to recognized high natural levels; with the provision that such additions are to be limited to vitamins or minerals or other dietary essentials, for which a wider distribution is considered by the Council to be in the interest of the public health.
>
> "The Council is opposed to the indiscriminate fortification of general purpose foods with vitamins or minerals or other dietary essentials. By fortification is meant the addition to a food of such an amount of a vitamin or other dietary essential as to make the total content larger than that contained in any natural (unprocessed) food of its class.
>
> "The following fortifications are recognized by the Council as being in the interest of the public health: (1) the addition of vitamin D to milk to an extent not to exceed 400 units per quart, no objection being made when the added vitamin is obtained from a natural source, if it carries with it one or more other vitamins; (2) the addition of vitamin A to substitutes for butter to an extent not to exceed the amount of vitamin A in butter of high natural content of vitamin A, no objection being made when the added vitamin is obtained from a natural source, if it carries with it one or more other vitamins; (3) the addition of iodine to table salt in an amount not to exceed one part of sodium or potassium iodide for each 5,000 * parts of salt; (4) the addition of calcium salts to cereal products in an amount such that the calcium content of the finished product does not exceed 0.075 gm. for each 100 calories; (5) the addition of iron to cereal products in an amount such that the iron content of the finished product does not exceed 0.0015 gm. (1.5 mg.) for each 100 calories."

It will be observed that by this resolution the addition of vitamins and minerals to foods was encouraged, with qualifications. Specifically, the qualifications were: (1) that only such vitamins and minerals should be added for which a wider distribution was considered desirable from the standpoint of the public health; (2) that for general purpose foods the additions in the case of products not previously accepted, vitamin D milk, vitamin A fortified margarine, and iodized salt, would be related to the amounts naturally present in foods of the class. In the discussion leading to this resolution, a sharp distinction was drawn between fortification and restorative additions of nutrients. Specifically encouraged were restorative additions of thiamine, riboflavin, and iron to cereal products, such as flour and white bread.

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[2] Cowgill, G. R.: The need for the addition of vitamin B_1 to staple American foods. Jour. Am. Med. Assoc. 113:2146-2151 (Dec. 9) 1939.

[3] Council on Foods and Nutrition, A. M. A.: Fortification of foods with vitamins and minerals. Jour. Am. Med. Assoc. 113:681 (Aug. 19) 1939.

* Later changed to 10,000.

This statement of policy served to stimulate several millers to experimental production of flours improved with respect to their content of thiamine. Bread brought up to whole wheat levels with respect to thiamine and riboflavin by the use of synthetic thiamine and defatted milk solids began to appear under encouragement from leading yeast companies. Likewise the American Medical Association policy served as a guide to subsequent action by the Food and Nutrition Board of the National Research Council, and influenced later actions taken by the Food and Drug Administration of the Federal Security Agency in the matter of enriched flour and enriched bread. The discussion preliminary to issuing this statement led also to consideration of the subject of food fortification at a meeting in Toronto, Canada, April 26, 1939, of the American Institute of Nutrition. A symposium was led by Agnes Fay Morgan, Lydia J. Roberts, W. H. Sebrell, E. M. Nelson, and Alonzo E. Taylor. The principle of fortification received serious consideration and all aspects of the problem were discussed.

Further Developments

Three events in the summer of 1940 precipitated developments: (1) a decision of the British Government, in July of that year, to fortify their flour and bread with thiamine; (2) a decision of the Subcommittee on Medical Nutrition, recently appointed in the National Research Council, to recommend re-enforcement with thiamine of all white flour purchased for the Army and Navy of the United States, and (3) a scheduling, for September 1940, by the Food and Drug Administration of public hearings to consider a proposal for a standard of identity for flour.

The British Government's decision to fortify flour and bread with thiamine, made in July 1940,[4] was actually never effected except for expeditionary military forces. British production of adequate supplies of thiamine was delayed by war conditions, and controversy developed over the private profits which might flow to vitamin manufacturers were all flour to be fortified. It was later that the British turned to their current so-called wheat meal loaf made from undermilled flour. It was later also (January 1942) that Canada announced its specifications for a long extraction flour, known as "Canada Approved". However, the first announcement of the British decision to fortify their flour, coming as it did when all eyes in America were turned to the Battle of Britain just beginning, did much to crystallize American thinking. The reasons for the subsequent course of action adopted by the British, under the circumstances in which they found themselves, will receive additional discussion later.

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[4] T. Moran and J. C. Drummond: Nature 146: 117 (1940).

The Subcommittee on Medical Nutrition, established in the early summer of 1940 under the Division of Medical Sciences of the National Research Council, confined itself primarily to military problems. However, in recommending fortification of flour with thiamine for use by the armed forces, it also expressed itself regarding the need for similar flour for the civilian population. The following statement appeared in the minutes of the second meeting of this subcommittee, August 5, 1940:[5]

> "It is generally agreed that the diet of the civilian population is minimal in its provision of Vitamin B_1, and in case of war the deleterious effect of an inadequate supply of vitamin B_1 is likely to manifest itself (unfavorably), especially in men doing heavy labor."

It was pure coincidence that the Food and Drug Administration's hearings on flour were scheduled at this same time. Flour, as defined in the preliminary announcement of the hearings, was ordinary white flour and unless testimony could be introduced into the record of the hearings showing it to be desirable to have in flour an amount of thiamine or other nutrient greater than that contained in the flour conventionally in use, the door would be closed to making additions of such nutrients, until the standard should be amended at some future hearings. The Subcommittee on Medical Nutrition was aroused by this proposal. So also were the Council on Foods and Nutrition of the American Medical Association and the several firms of millers interested in and experimenting with procedure in harmony with the recommendations of that Council. Dr. C. H. Bailey of the University of Minnesota had been engaged to study the technical problems involved, particularly those of nutrition, and had accumulated a mass of data on the occurrence of thiamine and riboflavin in various varieties of wheat and in the various mill streams encountered in a modern flour mill. Others were disturbed. The Surgeon General of the United States Public Health Service had been impressed by the Stiebeling-Phipard and other surveys revealing inadequacies in American diets, and he as well as Director Wilson of the Extension Service of the United States Department of Agriculture, who currently was heading a nutrition committee within the government, was convinced that improvement of the quality of bread was basic to any nutrition program that might be undertaken for national defense.

FLOUR HEARINGS, FOOD AND DRUG ADMINISTRATION

The flour hearings of September 1940 were attended by experts and consultants of flour milling and allied industries. Testimony respecting vitamin-containing flour was introduced by them. Other testimony placed in the record the previously cited recommendations of the Council on Foods and Nutrition of the American Medical Association. Members of the Subcommittee on Medical Nutrition of the National Research Council were also in attendance. Nearly all of the witnesses wanted something done to permit addition of nutrients to flour, but little agreement existed as to what should be done, and after many days a recess was declared. In this recess, at the instigation of Surgeon General Parran and Dr. M. L. Wilson, the executive officers of national associations of millers and bakers called a meeting in Chicago, inviting many leaders in these and allied industries, as well as a number of physicians and scientists, to participate. Among the latter were Doctors Boudreau, Nelson, Roberts, Sebrell, Spies, Stanley, Tisdall (from Canada), and Wilder. Other smaller meetings followed and the subject received consideration at a general meeting held by the American Institute of Baking, the American Bakers Association, and the Millers' National Federation. As a result, when the public flour hearings were reopened in mid-November, industry, science and government were thinking together as they had not been able to do before and harmony of opinion was obtained. In terms of technical knowledge, the millers had felt themselves prepared only for addition of thiamine to flour, whereas the nutritionists had held that the prevalence of pellagra and the increasing evidence of prevalence of ariboflavinosis called for niacin and riboflavin as well. Riboflavin at that time was not commercially available in more than meager quantities. The weight of testimony favored immediate addition of thiamine and niacin and a later introduction of riboflavin. The testimony also stressed the prevalence of iron-deficiency anemia and the addition of iron was strongly recommended.

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[5] Subcommittee on Medical Nutrition, National Research Council: Minutes of Meeting of August 5, 1940.

RECOMMENDATIONS FROM THE FOOD AND NUTRITION BOARD

The Food and Nutrition Board of the National Research Council, established as the Committee on Food and Nutrition, first assembled November 25-26, 1940, a week after the conclusion of the flour hearings. This Board had been established to provide scientific direction for the national nutrition program, which then was in the planning stage. The Board immediately gave consideration to the problem presented by flour and bread. It proposed to encourage the use of whole wheat or undermilled flours so far as this was feasible, but considered sympathetically the character of the testimony at the flour hearings. A general endorsement of the program for improving flour, which had been developed in those hearings, was given in the following resolution:

> "That the amounts of thiamine, nicotinic acid, and other nutrients recommended by the subcommittee on nutrition, endorsed by the Council on Foods and Nutrition of the American Medical Association and presented in the testimony before the Food and Drug Hearings November 14, 1940, by Wilder, Sebrell, Jolliffe, and Williams, be endorsed by this Committee."

While the newly organized Committee, which later became the Food and Nutrition Board, discussed a broad program to improve the nutritional status of the American people, the prevailing thought was evident that flour and bread enrichment was to be a prime implement for the purpose. It has continued to occupy the position of a central theme in the program of the Board. At the time that the resolution relating to flour was adopted, a committee was appointed to study the development of related standards for white bread. The recommendations of this committee were adopted later. In their preparation, Mr. Schumaker, President of the American Bakers Association, Dr. Tobey, Director, Department of Nutrition of the American Institute of Baking, and Mr. Thomas, an executive officer of General Mills, representing the interests of millers and bakers, cooperated with Dr. Nelson of the Food and Drug Administration, Dr. Sebrell of the United States Public Health Service, and members of the Board. The standards suggested for bread were so designed that the advantages of an improved flour could be carried over to bread, and a baker, using the new flour, automatically would produce a bread with nutritional improvement comparable to the flour. At the same time it was recognized that the baker had at his disposal other methods for incorporating the desired vitamins and minerals in his loaf. The use of synthetic thiamine and defatted milk solids by certain bakers for a portion of their production was established in 1939. A major factor contributing to the extension of the practice of enrichment at the bakery was the development, at about that juncture, of a process for producing yeast unusually high in thiamine, fathered by Standard Brands, Incorporated. (See U. S. Patents Nos. 2,262,735, November 11, 1941, and 2,285,465, June 9, 1942, both to A. S. Schultz, Lawrence Atkin, and Charles N. Frey, assignors, to Standard Brands, Inc.) This high-vitamin yeast was offered at some cost advantage over synthetic thiamine, as the final step of synthesis was effected in vivo by the yeast from synthetic intermediates added to the medium. For a period of about two years, enrichment of bread was accomplished largely by the use of this type of yeast, which presently also came to be supplied by other companies making yeast. The principle of allowing latitude as to the mode of enrichment and of insisting only upon the nutritional quality of the final product as delivered to the retail consumer, was appreciated by the bakers.

One of the first undertakings of the Food and Nutrition Board was to assist in organizing a National Nutrition Conference for Defense.[6] This conference took place in Washington, at the call of President Roosevelt, May 27, 1941. By that time standards had been fixed and established for enriched flour and certain other kindred products. Also the name *enriched* had been decided on. The question of a name for the improved product had aroused discussion. The industries had favored a coined word that could be copyrighted. The committee had preferred the word "restored" which would more adequately indicate the nature and direction of the changes made in plain white flour and white bread. The word "enriched", however, was found most acceptable to the Food and Drug Administration and all parties subsequently agreed to it.[7] Hearings had been announced concerning the enrichment of bread. No official regulations had been issued regarding bread and, indeed, for a variety of reasons which will appear below, these regulations have not yet appeared. However, an understanding had been reached among the Food and Nutrition Board, the Food and Drug Administration, and the American Bakers Association that enrichment of bread in accordance with the recommendations which had been made by the Food and Nutrition Board to the Food and Drug Administration would be accepted as compliance with the Federal Food, Drug, and Cosmetic Act. Accordingly, it was possible to inaugurate enrichment of bread as well as flour on the occasion of the Washington conference in May 1941. Enrichment of bread still continues to be practiced upon this informal basis, except as regulated by an order of the War Food Administration which since January 1943 has required enrichment of all baker's white bread (and later rolls).

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[6] Proceedings of the National Nutrition Conference for Defense, May 26-27-28, 1941, U. S. Government Printing Office, Washington, D. C., 1942.

The Conference endorsed the action of the Food and Nutrition Board respecting flour and bread enrichment. In that conference, and later, some nutritionists and a few millers and bakers opposed the synthetic approach to correction of a dietary staple. A few other millers have been opposed on other grounds. The program, however, has steadily gained support as its practicality has become more evident with experience. By the close of 1942 the cooperation of millers and bakers had led to voluntary enrichment of from 75 to 80 percent of all family flour and baker's white bread, and decisions had been reached that the flour in use in the Army and Navy and all Federal institutions must be enriched. At the present time six states have laws requiring enrichment of all family flour and baker's bread.

Enrichment of family flour and baker's white bread has led to great improvement in the American diet. It is naturally difficult at this early date to provide an entirely satisfactory demonstration that this has been followed by improvement of the public health. It should be of some significance, however, that Dr. Jolliffe, of the New York University College of Medicine, could testify as follows at a public hearing held by the War Food Administration, January 21, 1943: "I attribute to bread enrichment a marked and unmistakable decrease in the incidence of florid beriberi and florid pellagra in my wards at Bellevue Hospital. In 1938-39 little bread was enriched; in 1942-43, 75 percent or more has been enriched in New York City. This has been accompanied by a decrease of three-fourths in our cases of florid beriberi and of two-thirds in florid pellagra."

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[7] Federal Register, 6, May 27, 1941, 2574-2582.

CHAPTER II

LEGAL IMPLEMENTS AVAILABLE

Brief reference has been made to the flour hearings of September and November, 1940, at which the addition of vitamins to white flour was first proposed for official sanction. Contrary to a commonly held idea, the sanction which has been given to enriched flour and bread under the Federal Food, Drug, and Cosmetic Act is entirely permissive. Without further legislation it is impossible for the food and drug authorities to require the enrichment of these products. However, the sanction which has been afforded has been very influential in encouraging the practice of enrichment by both millers and bakers.

Character of Food, Drug, and Cosmetic Act

The Food, Drug, and Cosmetic Act of 1938 is entitled "An Act to Prohibit the Movement in Interstate Commerce of Adulterated and Misbranded Food, Drugs, Devices, and Cosmetics and for Other Purposes." The provisions regarding foods differ in certain respects from those regarding drugs but in both instances it is the prohibition of interstate commerce in adulterated and misbranded products which is sought. Accordingly, in order to restrain, under this Act, interstate commerce in unenriched white flour it would be necessary to establish that it is either misbranded or adulterated.

Consideration has been given to both of these possibilities. Section 402 (b) provides that a food shall be deemed to be adulterated "if any valuable constituent has been in whole or in part omitted or abstracted therefrom." On its face, this provision might appear to apply to white flour. However, white flour has so long been established as an article of commerce that the term "flour" has taken on the commonly accepted meaning "white flour." Indeed, in accordance with a regulatory announcement issued November 1936 by the Food and Drug Administration, flour was defined as "the fine ground product obtained in the commercial milling of wheat consisting essentially of the starch and gluten of the endosperm. It contains * * * not more than one percent of ash. * * *" Clearly, it would be violative of fundamental principles of law to use language in other than its commonly accepted meaning. The product flour, having been accepted for years as wholesome, cannot be ruled to be adulterated because of recently acquired knowledge of its nutritional faults except by special legislation. For the same reason a white flour sold as flour cannot be deemed to be misbranded.

However, the Food, Drug, and Cosmetic Act contains a provision whereby it appeared possible to give sanction to a flour having superior nutritional qualities. This provision is found in Section 401, as follows:

> "Whenever, in the judgment of the Administrator, such action will promote honesty and fair dealing in the interest of consumers he shall promulgate regulations fixing and establishing for any food,

> under its common or usual name, so far as practicable, a reasonable definition and standard of identity, a reasonable standard of quality and/or reasonable standards of fill of container."

It was under this provision of Section 401 that nutritionally improved white flour and bread were first presented to the Federal Security Agency for approval.

Although the Federal Food, Drug, and Cosmetic Act bears directly only upon interstate commerce in such products, the prestige of the Federal Food and Drug Administration is extremely influential in the several states. To a large degree the State Food and Drug Laws are patterned after the Federal law and State authorities have commonly been guided by the principles laid down in the regulations of the Federal Administration. Many of the states and cities have special regulations concerning particular products but in general there is a high degree of conformity to the Federal pattern. Moreover, since the larger manufacturers of food and drug products engage in interstate commerce and find it convenient to market under uniform labels throughout the country, there is a general conformance to the Federal law. Conformity to the Federal law is a sales asset even in the case of strictly intrastate commerce. For these reasons millers and bakers interested in nutritional betterment of their staple products attach a great deal of importance to a permissive recognition of the improved variety of bread and flour now known as "enriched."

Under regulations promulgated by authority of the Federal Food, Drug, and Cosmetic Act the character of labeling of food and drug products is rigorously controlled. However, the authority of the Act with regard to the character of the advertising of food products is essentially limited to the printed material on or accompanying the package. Newspaper, magazine, and radio advertising is not subject to the provisions of the Act. The Federal Trade Commission has authority to deal with fraudulent or misleading advertising with regard to commercial articles of all sorts, an authority which it exercises with special zeal as regards food products. This is a reflection of the high popular esteem in which our pure food law is properly held.

SPECIAL PROBLEMS PRESENTED BY ENRICHMENT

Obviously, the Food, Drug, and Cosmetic Act was not ideally suited to deal with the problem of "enrichment" of bread and flour. Even the fixing of a definition and standard of identity for the product offered some special difficulties. The first of these lay in the fact that such an "enriched" product had not yet become a familiar article of commerce and had acquired no "common or usual name," and, indeed, could not do so until a significant interstate commerce in the product should be permitted to arise. Actually, at the flour hearings of November 1940, the testimony of nutritionists was directed to the fixing of a definition of a flour of nutritional quality more suitable for general use but little reference was made to the name whereby it should become known. Several names were suggested by various witnesses, a number of them being in the nature of coined words. One of the names mentioned was the term "enriched" but this term received only casual attention at the time and was not specifically endorsed by the majority of the witnesses supporting the new grade of flour. Responsibility for the choice of the name lay with the officials of the Federal Security Agency under which the Food and Drug Administration is organized. The first official proposal of the use of this term is in the announcement of the proposed order of the Federal Security Administrator of March 28, 1941.[8]

The term was not at first very popular with the milling and baking industries and many members of the Food and Nutrition Board expressed disappointment in the choice. However, as the program proceeded the term gained rapidly in popularity and promptly achieved the status of a slogan word. Without some such term as an aid to the program it is doubtful whether the practice could have been popularized. The term has been criticized by many nutritionists as too laudatory of the character of the product. It is argued that enriched flour is not richer than some other wheat flours and that, accordingly, the name is not justified. From the standpoint, however, of the food and drug authorities the term flour is synonymous with ordinary white flour. As compared with ordinary white flour, under this legal definition, there can be no doubt that the new product is genuinely enriched. There is no other term which commands more general support. In any public movement of this sort one must deal with the situation as it exists, though he may wish that embarrassing precedents were absent. Decision as to whether one will or will not support the measure must be based upon the overall merit of the proposal, not on minor details.

Another major issue which arose at the 1940 flour hearings was the choice of a proper basis for addition of nutrients. Much of the testimony at those hearings compared the nutritional quality of white flour with that of old-fashioned water-ground flour and many of the witnesses favored raising the nutrient levels to those of the old-fashioned product. Others thought that whole wheat should be taken as the model. On the other hand, there were witnesses who argued that in adding vitamins to flour the nutritional needs of the mass of the population should be taken as the sole criterion. In the view of these witnesses, it was immaterial whether the nutritional qualities of the new flour should correspond either to those of old-fashioned flour or to those of whole wheat flour. They regarded it as essential, however, that the new product should repair the short-comings of the overall American dietary in so far as it was practicable to do so through the medium of flour. Legal minds were agreed that the new standards could best be defended in court if they were based on ascertained needs of the population rather than on a general philosophy that natural foods are the best patterns of human need. The debate on this issue still continues, although certain practical compromises have been reached. Neither philosophy is followed with entire consistence in the standards which have been set.

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[8] Federal Register *6*, 1729 to 1737, April 1, 1941, See Appendix A, 3.

Attention should be called to the fact that enriched flour under the official definition may be produced by the addition of natural or synthetic vitamins or by the retention of the vitamins native to the grain. It seemed clearly unsound to establish a definition which would permanently prohibit millers from achieving the desired nutritional standard by adaptation of their milling processes. Experience in securing public support for the enrichment program has revealed a strong preference on the part of students of nutrition for natural means of achieving nutritional betterments. Consequently, many who were inclined to this doctrine were reconciled to the enrichment program largely by the consideration that the enriching process could be carried out by retention of natural vitamins and that the effect of enrichment, even when synthetic vitamins were used, was to render the flour more nearly equivalent to the natural whole wheat product.

This type of consideration also led all authorities to favor the addition of vitamins only within the general range of their occurrence in whole wheat but, as we shall see, owing to other considerations, the level of riboflavin ultimately fixed exceeds that present in the whole grain. This now makes it impossible practically to achieve enrichment entirely by the natural route. Even were the riboflavin level lowered, the practical difficulties of enrichment wholly by retention from the grain would still be great. It would not be practicable commercially to mill the wheat in such a manner as to retain the vitamins while excluding a large fraction of the ash constituents of the grain.

Under the terms of Section 401, quoted above, it is to be noted that "promotion of honesty and fair dealing in the interest of consumers" is the criterion which the Administrator is required to follow in establishing a definition and standard of identity. While the Act prohibits the addition to foods of substances deleterious to health, it makes no specific provision for the Administrator to require dietary adequacy in foodstuffs by fixing suitable standards. There was, therefore, some question as to the extent to which the Administrator was authorized to take into account public health considerations in connection with the fixing of such a standard. Under the Act, if the consumer is honestly informed with regard to the character of the food product and if no deleterious ingredient is added, the consumer is assumed to be capable of choosing a suitable dietary. Modern nutritional science tells us that people are very likely to choose wrongly, especially under the pressure of poverty, and we may some day have to rewrite our pure food law to be more consistent with modern principles of nutrition.

The reader's attention should be called to the customary routine followed by the Federal Security Agency in arriving at and promulgating an administrative order such as those covering definitions of enriched products. First, an announcement is issued giving notice of hearings to be held and specifying precisely the subject matter which is to be considered at the hearings. Usually there is included in this notice a statement of the provisions which the Administrator considers wise or necessary in the case. These initial proposals are not binding except as they describe the scope of the subject matter of the hearings. Some weeks or months following the hearings, the Federal Security Agency publishes its proposed findings of fact, as disclosed at the hearings, and a set of proposed administrative regulations. Interested parties who participated in the hearings are invited to set forth any objections which they may have to the proposed findings and regulations. If such are submitted, they are reviewed by the Federal Security Agency, which may issue the order over such protest, or, if the protest is well taken and comes within the scope of the testimony given at the hearings, the Federal Security Agency amends its order. If the protest concerns a vital matter not covered by the testimony at the hearing, new hearings may be called. A final order is eventually published, which stands as an administrative regulation, subject only to review by the courts. Reference to Appendix A will reveal each of these successive steps in several instances as part of the proceedings relating to enrichment orders. Readers are cautioned not to confuse proposed orders with final orders.

CHAPTER III

SUCCESSIVE STEPS IN FIXING PRESENT STANDARDS

The standard for enriched flour as first issued on May 27, 1941, required the presence in each pound of flour of 1.66 milligrams of thiamine, 1.20 milligrams of riboflavin, 6 milligrams of niacin, and 6 milligrams of available iron. In addition, the producer was allowed the option of including calcium to the extent of not less than 500 milligrams nor more than 2,000 milligrams per pound of flour, and vitamin D to the extent of not less than 250 U. S. P. units and not more than 1,000 U. S. P. units.[9] The standard was not to become effective until January 1, 1942, at which time the Administrator hoped to find the commercial supply of riboflavin adequate for the purpose.

The basis for the above levels of the required ingredients was, according to the official findings, to be found in clinical evidences of deficiencies in the population, in estimated shortages in intake of these nutrients provided by the typical American dietary, and in certain assumptions as to the extent to which flour, on the average, enters into the dietary. Those who had supported enrichment at the flour hearings supposed that these levels were also substantially consistent with the levels of these nutrients found in old-fashioned water-ground flour. Actually, it later developed, serious errors existed in the then available data on the content of both niacin and riboflavin in foodstuffs, and particularly in cereals, because of faulty methods of analysis. Subsequent reconsideration of these values was, therefore, required. (See Chapter IV.)

However, the original order giving sanction to the enrichment of flour contained features relating to farina which proved to have more immediate significance for the welfare of the program than the above errors. Farina had been considered at the same hearings as flour and a definition of "farina" was adopted which did not permit the addition of any vitamins to it. At the same time a definition of "enriched farina" was issued which required the presence of thiamine, riboflavin, nicotinic acid, and iron in the same minimum proportions as were prescribed for enriched flour. As optional ingredients, vitamin D might be added to enriched farina in amounts not less than 250 U. S. P. units and calcium in amounts not less than 500 milligrams per pound of farina.

Very shortly after the issuance of this order, a farina manufacturer who had for some years been marketing a farina to which vitamin D alone had been added, filed a petition for a judicial review of the order in the Circuit Court of Appeals in accordance with a provision of the Food, Drug, and Cosmetic Act granting that privilege to any person adversely affected by such an order. The principal ground for this action was that the petitioner's business in vitamin D-fortified farina was, according to the petitioner, destroyed by this order of the Federal Security Administrator. A farina fortified with vitamin D alone could not be sold either under the new standard for

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[9] Federal Register 6, 2574, May 27, 1941, See Appendix A, 4.

"farina" nor under the new "enriched farina" standard. In order to continue the addition of vitamin D to farina the manufacturer would be compelled to add also thiamine, riboflavin, nicotinic acid, and iron in certain proportions. It was claimed that the expense of adding these additional nutrients would be burdensome. The petitioner went farther, however, to allege that, since the product which he had been selling was undeniably wholesome, the promulgated standards for "farina" and "enriched farina" were arbitrary and unreasonable, and that the Administrator had exceeded his authority in promulgating them. While the petitioner refrained from attacking the standard for enriched flour and confined his arguments entirely to the matter of farina, the petition appeared to offer a threat to the authority of the Federal Security Administrator for issuing such a standard as that for enriched flour as well.

The issue here raised is really quite fundamental to the enforcement of the Food, Drug, and Cosmetic Act by means of definitions and standards of identity. The position taken by the Government was that the Administrator has authority to define very narrowly and in detail what a product sold under a specified name shall thereafter contain. He may require the presence of certain ingredients and the absence of others; he may permit certain optional ingredients and deny inclusion of others when, in his judgment, "honesty and fair dealing in the interest of the consumer" are thereby promoted.

According to the petitioner's viewpoint, each producer of a product should be permitted to add any wholesome ingredient which makes the product attractive to the public, provided only that he truthfully states on the label what he has added. At the flour hearings there were witnesses for other elements of the industry who also favored leaving the choice to the manufacturer as to what ingredients, if any, he should add, assuming, of course, wholesomeness of the product and truthfulness of labeling. We might thus have had "enriched flour" containing any one or any combination of the vitamins in great diversity but all called "enriched."

There is reason in each viewpoint. Under a free economy, invention of new, attractive, and wholesome food products should not be stifled by bureaucratic controls. Without adequate legal checks and safeguards it is conceivable that a zealous administrator might carry out such an extensive and detailed program of defining all foods on the market that a new, meritorious product could be promoted only under some fanciful or arbitrarily chosen name which would convey no meaning to the public. To illustrate: the administrator might so define cake that some new but wholesome and appetizing fruit could not be incorporated in a product sold as cake. The food manufacturer would thus be deprived of a privilege prized by the housewife of concocting new recipes. But the law contains very definite safeguards against such arbitrary action. It requires the Administrator, upon the application of any interested industry or substantial portion thereof stating reasonable grounds therefor, to hold a hearing upon their proposal to issue, amend, or repeal any standard. The Administrator can thus be forced to consider new and desirable developments in food technology. And if the Administrator's action in issuing, amending, or repealing the standard, or in refusing to do so, is unreasonable, arbitrary, or capricious, or is not such as to promote honesty and fair dealing in the interest of consumers, or is otherwise not in accordance with the law, the courts are empowered to set aside the Administrator's action or refusal to act and to direct him to proceed in a legal manner. That this statutory scheme operates to insure care and fairness in the formulation of standards is indicated by what transpired in the farina case and in others decided by the courts.

The attack of the petitioner on the so-called exclusive appropriation theory above outlined has served as a useful warning that there are limits beyond which the definition of foodstuffs cannot safely be carried. It seems probable that the authority to define should not be exercised as to non-staple products except to correct a specific abuse or an existing confusion or ambiguity of terms.

As to staple products, however, other considerations appear paramount. No staple food can soundly be considered apart from the dietary as a whole. If a program of corrective additions such as the enrichment program is justified, it must aim at insuring that a housewife going to the grocery to buy food in accordance with the prevailing dietary pattern does not expose her family to a gross deficiency of any necessary nutrient. With the advent of potent synthetic nutrients, a policy which permitted their addition to staple foods, according to the sales instinct of each producer, would result almost certainly in preposterous over-fortification of the usual dietary with some vitamins and probably in neglect of others.

The hazard of the petitioner's attack appeared to be greatly augmented by the character of the decision of the United States Circuit Court of Appeals for the 7th Circuit, which was issued on June 26, 1942. A few paragraphs quoted from this decision will serve to illustrate the threat to the proposed enrichment program.

> "A study of the record leaves no room for doubt but that the hearing revolved largely around consumer interest as it related to health. In referring to the ingredients of enriched farina, it is stated in respondent's brief: 'They are essential to the health and well being of our nation.' In support of the regulations it is also suggested that they will prevent confusion among consumers as to their nutritional needs. In this regard respondent states: 'Indiscriminate enrichment with vitamins and minerals would tend to confuse and mislead consumers by giving rise to conflicting claims regarding the beneficial effects of various vitamins and minerals and would be likely to lead to the impression on the part of consumers that a single article of food so enriched would meet all nutritional needs. . . . .'"
>
> "That the promotion of honesty and fair dealing was intended by Congress to mean something other than the promotion of the Consumer's health is plainly ascertainable from a study of the Act. Likewise it is clear that action was not authorized merely to avoid confusion on the part of consumers nor to educate the public as to dietary requirements. If Congress had so intended it would no

> doubt have employed the appropriate language. While there may be some relevancy between the promotion of health and that of honesty and fair dealing, they certainly are not synonymous terms. Injury to health does not necessarily follow from dishonesty and unfair dealing in food products and neither does health improvement necessarily follow from honesty and fair dealing."

In the concluding paragraph of the decision written by Circuit Judge Major there appeared the following:

> ". . . . . the regulations, while purporting to be in the interest of consumers, do not promote honesty and fair dealing in their behalf. On this statutory requirement essential to respondent's authority to act the record is wholly deficient. In view of this situation, the action of respondent in promulgating the regulations in controversy was beyond his statutory authority. Such being the case they must be set aside. It is so ordered."

It is evident from this decision that the entire enrichment program was imperiled thereby, though the product farina which was in dispute is consumed in minor volume as compared with flour. The nutritionists who testified at the flour hearings, which furnished a basis for the Administrator's order, had paid scant attention to the farina matter in their testimony. This is ascribed to their unfamiliarity at that time with the problems of law enforcement relating to food products.

In retrospect it has become evident that the enrichment program would have been relieved of much embarrassment if farina had not been included among the subject matter of the hearings. Farina is not a staple food product consumed in high proportion by the mass of the people. It is used in modest proportion as a breakfast cereal by a certain percentage of the adult population and in addition is a popular infant food. In so far as it is a breakfast cereal for adults, it is questionable whether it is consumed in sufficient amounts by any substantial number of people to require a special standard of identity. In so far as it is a widely used infant food, the appropriate additions of nutrients to it must be judged upon the special needs of the infant. However, farina is, in effect, a product of a stage in the milling of wheat to produce flour and compositionally is white flour in the form of relatively large granules. It was on this apparently logical ground that it was included in the subject matter of the flour hearings.

The promulgation of a standard for enrichment of farina has offered some embarrassment to the Food and Nutrition Board in that it provides a precedent for asking for official standards for numerous other breakfast cereals, should the manufacturers of them so desire. The maturer thinking of the Board has led to the conclusion that systematic enrichment of foodstuffs ought to be limited to certain staples of such general distribution as to require attention in any adequate national nutrition program. Random fortification of foods in general is foreign to the Board's aims. This subject will be further discussed on later pages.

The practical importance of the farina case in relation to the enrichment program was the clear threat to the authority of the Federal Security Administrator to issue such a standard as that for enriched flour. Had the decision stood, any miller opposing enrichment would probably have had little difficulty in having the enriched flour standard set aside by an appropriate petition to the courts. On account of the threat of this decision, the Federal Security Administrator refrained from calling further hearings with regard to products for which enrichment was proposed. For about two years, this made it impossible to secure a correction of the errors in the original standard fixed for enriched flour growing out of analytical difficulties above mentioned.

The Federal Security Administrator petitioned the Supreme Court, in its October 1942 term, for a writ of certiorari to the Circuit Court of Appeals. This writ was granted; the Supreme Court reviewed the evidence in the case and issued its decision on March 1, 1943, reversing the action of the lower court. In this decision, delivered by Chief Justice Stone, Justice Roberts dissenting, the contentions of the Government were amply supported. The following quotations from the Supreme Court decision are of significant interest:

> "For reasons already indicated, we think that the evidence of the desire of consumers to purchase vitamin enriched foods, their general ignorance of the composition and value of the vitamin content of those foods, and their consequent inability to guard against the purchase of products of inferior or unsuitable vitamin content sufficiently supports the Administrator's conclusions . . ."
>
> "Stated in another form the argument is that it is unreasonable to prohibit the addition to farina of vitamin D as an optional ingredient while permitting its addition as an optional ingredient to enriched farina to the detriment of respondent's business . . ."
>
> "We cannot say that the Administrator made an unreasonable choice of standards when he adopted one which defined the familiar farina of commerce without permitting addition of vitamin enrichment, and at the same time prescribed for 'enriched farina' the restoration of those vitamins which had been removed from the whole wheat by milling and allowed the optional addition of vitamin D commonly found in milk but not present in wheat. Consumers who buy farina will have no reason to believe that it is enriched. Those who buy enriched farina are assured of receiving a wheat product containing those vitamins naturally present in wheat and, if so stated on the label, an additional vitamin D not found in wheat . . ."
>
> "We conclude that the Administrator did not depart from statutory requirements in choosing these standards of identity for the purpose of promoting fair dealing in the interest of consumers and that the standards which he selected are adapted to that end and that they are adequately supported by findings in evidence. Reversed."

This decision cleared the way, after a long interval of suspense, for further systematic and necessary steps for correcting and extending the enrichment standards.

The next step in perfecting the enrichment standards followed promptly after the decision of the Supreme Court on March 1, 1943, as cited above. Notice of hearings on both enriched bread and enriched flour was issued on March 17, 1943.[10] The hearings began on April 19, 1943 and embraced a review of the principal testimony given at the preceding flour hearings and bread hearings and a discussion of some detailed questions which had arisen in the intervening time. The primary purpose of combining the consideration of enriched bread and flour in a single hearing was to bring the ultimate regulations for the two products into thorough consistency with one another. The proposed order amending the definitions and standards of identity for enriched flour and farina followed on June 4, 1943,[11] and the final order for enriched flour, dated July 1, 1943, was issued to take effect October 1, 1943.[12] It prescribes the following requirements:

NUTRIENT REQUIREMENTS FOR ENRICHED FLOUR
(As amended, Effective October 1, 1943)

	Minimum	Maximum	
Thiamine	2.0	2.5	mgs. per pound
Riboflavin	1.2	1.5	" " "
Niacin	16.0	20.0	" " "
Iron	13.0	16.5	" " "
Calcium, optional*	500	625	" " "
Vitamin D (not changed) optional	250	1000	U. S. P. units

* Required in self-rising flour, min. 500 mgs., max. 1500 mgs., per lb.

A proposed order on definitions and standards of identity of various kinds of bread was issued July 29, 1943.[13] This proposed order is also reproduced in abstract in Appendix A, 16, as it constitutes the latest official expression of intention with regard to enriched bread standards. The final order covering enriched bread has not yet been issued. Two facts intervened to prevent its issuance.

First, owing to the advancing events of war, emergency measures were deemed necessary. A Food Distribution Administration was set up December 5, 1942, to care for the special problems of civilian food supply. On April 19, 1943, this was merged into a newly created War Food Administration, which assumed responsibility for food supplies for our allies, as well as those for our own civilian population. Of necessity, the War Food Administration also worked with the military authorities in reconciling the competitive demands for military and civilian purposes. The first order of the Food Distribution Administration had to do with the bread supply and, among other regulations, included a requirement that all white bread should be enriched in a manner consistent with the existing standard and definition for enriched flour. The issuance of this war order governing the enrichment of bread rendered less urgent the promulgation of a final peace-time standard for the enrichment of bread.

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[10] Federal Register *8*, 3378, March 19, 1943. See Appendix A, 12.

[11] Federal Register *8*, 7511, June 5, 1943. See Appendix A, 13.

[12] Federal Register *8*, 9115, July 3, 1943.

[13] Federal Register *8*, 10780, August 3, 1943.

The other event which intervened to halt the issuance of a standard for enriched bread was the filing of numerous pleas by certain elements of the baking industry and by the purveyors of soya flour and other kindred products. These petitioners asked for new hearings on enriched bread with the avowed purpose of including in the standard to be issued certain permissive proportions of vegetable products high in protein. They found support for this plea in the existing and prospective short supply of meat and the diminished amount of skim milk powder available for bakers' use. Skim milk powder has been exported during war time to our allies in very large amounts and has proved one of the most valuable contributions which we have been able to make to the British dietary. Further discussion of the issue of high protein additions to bread will follow in a later chapter. It is sufficient to say here that the Federal Security Agency has been reluctant to embody in permanent peace-time regulations such temporary measures as may be peculiar to war time. War Food Administration, on the other hand, hesitates to inaugurate new quality standards for foodstuffs which may appear inconsistent with, or even in conflict with, the existing permanent peace-time standards. The matter continues in suspense, by agreement between the Federal Security Agency and War Food Administration, as disclosed in the following press release of April 9, 1944:

> "Action on proposed bread standards under the Food, Drug, and Cosmetic Act has been postponed in the interest of flexible war food management, according to an announcement made today by Federal Security Administrator Paul V. McNutt. This postponement, Administrator McNutt said, was suggested by the War Food Administration.
>
> "The agreement was reached on the basis of joint investigation of all the issues involved by the Federal Security Agency's Food and Drug Administration and the War Food Administration. In raising the question, the latter had pointed out that it is desirable to continue the permissive use of certain ingredients, such as soybean flour and dried whey, not permitted by the proposed standards; that changes may later become necessary involving modification of bread compositions which would not be allowed under the proposed standards; that if they are not in effect, such changes could be brought about by amending the War Food Administration's Food Distribution Order No. 1. The interests of both agencies will be centered on adopting all practicable measures for the maintenance of consumer protection.
>
> "Extensive hearings were held in 1941 and 1943 on standards for bread, rolls, and related products. Testimony was received from millers, bakers, nutritionists, representatives of consumers' groups, and others concerned. The findings of fact resulting from these

> hearings led to the compilation of proposed standards which provided for limitations against excessive moisture, the exclusion of certain proposed ingredients regarded as unsuitable for use in breads, fixed quantities of certain minerals and vitamins in enriched bread, and regulation of the quantities and conditions of use of a large number of ingredients.
>
> "The findings of fact and the proposed standards were published in the Federal Register for August 3, 1943, with an invitation to file exceptions on the basis of which further consideration might be given to the entire question. The conferences between the Federal Security Agency and the War Food Administration, out of which has come the decision to postpone further action, followed this publication of the proposed standards."

The enrichment program continues without serious impediment. As far as enriched flour is concerned, the program is still one of voluntary action, except as a few states have passed mandatory legislation. Enrichment of all white bread and white rolls now proceeds under the above mentioned war order in a manner consistent with the proposed standard (Appendix A, 16).

CHAPTER IV

ISSUES CONSIDERED AT THE HEARINGS

While the matter was in the hands of the courts from May 1941 to March 1943, no formal actions could be taken to perfect the standards, but a great deal of informal progress was made toward consolidating and unifying opinion on enrichment.

First, there was the understanding of January 26, 1941, among the Food and Nutrition Board, the Food and Drug Administration, Millers' National Federation, and the American Bakers Association, referred to in an earlier chapter of this writing, that bread as well as flour would forthwith be enriched despite the absence of official standards for enrichment of bread, and despite the fact that those for enriched flour were yet to be made final by the Food and Drug Administration. The standards for enriched bread, pending Food and Drug Administration hearings relating to bread, were to be those recommended by the Food and Nutrition Board, then the Committee on Food and Nutrition. The standards for bread recommended at that time by the Board[14] were as follows:

RECOMMENDATIONS FOR ENRICHED BREAD
(As Proposed, January 1941)

Per Pound of Bread	Minimum mg.	Maximum mg.
Thiamine	1.0	2.0
Niacin or niacinamide	4.0	8.0
Iron	4.0	16.0
Riboflavin (optional)*	0.8	1.6
Calcium (optional)	300	1200

*The optional feature was not adopted, in view of the decision to require riboflavin in enriched flour.

Riboflavin was to remain optional only until procurement problems were solved. No recommendations were made respecting phosphorus or vitamin D.

Fortunately, an announcement of hearings relating to enriched bread had been issued prior to the adverse decision of the Circuit Court of Appeals in the Farina case mentioned in Chapter III. Had the bread hearings been omitted at this time or long deferred, the enrichment program would have been greatly handicapped, for it was at these hearings that the views of the baking industry regarding enrichment were crystallized. Special problems relating to enrichment were aired and the hearings provided a liberal education in the problems that had to be faced for all who were concerned.

The hearings were convened on July 7, 1941, and finally adjourned on August 15, 1941. It will, perhaps, be surprising to many who have not been concerned with proceedings such as this to learn that more than thirty days of continuous session were necessary to present all of the appropriate evidence concerning the variety of matters relating to bread, which constituted the subject matter of the hearings. It should be made clear that much of the testimony related to minor constituents of bread and other bakery goods and to a great variety of industrial practices and precautions which are more or less unfamiliar to the lay public. Regulations concerning the great variety of specialty breads were also under consideration at the same hearings. However, many days were devoted to consideration of the problems specifically connected with the enrichment of white bread. Such lengthy proceedings at such hearings are not unusual. The hearings on flour were nearly as long. A total of about 7,000 typed pages of testimony was taken of the two hearings. Critics of the program must recognize that any democratic procedure is likely to require compromises among a great variety of conflicting, but wholly legitimate, interests which must have their day in court. The result can rarely meet the unqualified approval in every detail of any one vitally concerned and its merits must be judged on an overall basis.

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[14] Bulletin, Food and Nutrition Board, pp. 74-75, January 27, 1941. Mimeographed.

At the above mentioned bread hearings, the testimony presented at the preceding flour hearings was systematically and critically reviewed and the corrections which would be needed at the proper time were set forth. At the joint flour and bread hearings in April 1943, the previous records of hearings relating to enrichment of flour and bread were incorporated into and made a part of the record. The informal standards temporarily adopted in May 1941 by the baking industry on recommendation of the Food and Nutrition Board necessarily conformed to the somewhat defective standards for flour which had been issued. It was understood, however, that when the flour standards were amended, corresponding amendments of bread enrichment would go into effect. Accordingly, when the new standard for flour took effect on October 1, 1943, it automatically carried over into the bread field.

The new and old standards are compared below:

ENRICHMENT STANDARDS

(Milligrams per pound, unless otherwise stated)

Required	Flour Standard (Official)				Bread Standard (Informal)			
	Old[1]		New[2]		Old[3]		New[4]	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Thiamine	1.66	2.5	2.0	2.5	1.0	2.0	1.1	1.8
Riboflavin[*]	1.2	1.8	1.2	1.5	0.8	1.6	0.7	1.6
Niacin	6.0	24.0	16.0	20.0	4.0	16.0	10.0	15.0
Iron	6.0	24.0	13.0	16.5	4.0	16.0	8.0	12.5
Optional								
Calcium[**]	500	2000	500	625 ~~1500~~	300	1200	300	800
Vitamin D, U.S.P. Units	250	1000	250	1000	...	...	150	750

[1] Appendix A, 4
[2] Appendix A, 15
[3] Appendix C, Jan. 29, 1941.
[4] Appendix A, 16.

[*] Riboflavin requirement deferred, ultimately to October 1, 1943.
[**] Required in self-rising flour, min. 500 mgs., max. 1500 mgs., per lb.

The progress which was made at the several hearings in the resolution of questions arising relating to enrichment has a considerable historical interest. The story may well be of service to those who are faced with the problem of securing the enactment of enrichment legislation in any of the several states or in aiding in the intelligent enforcement of the existing regulations.

The prime reason for need to revise the first flour standards was that, owing to wrong methods of analysis, wrong ideas were current in 1940 about how much niacin and riboflavin are present in certain important foods, especially cereals. Consequently, because the ideas of human needs for these vitamins are derived largely from observation that certain symptoms appear when the level of niacin or riboflavin is too low, false ideas of the amounts present in various diets threw the calculations of human needs all awry.

We should not be too critical of the chemists for not knowing how to analyze for vitamins. They are newly identified substances mixed in very minute proportions with a host of other materials which give a variety of confusing reactions. These problems had been studied only in part and only a few chemists had become familiar with them. Thiamine analysis was much more nearly perfected than that for riboflavin and niacin. However, large disagreements between laboratory and laboratory were extremely frequent, even in the case of thiamine. Only a few of the laboratories which had been studying the subject the longest could obtain consistent results.

As regards riboflavin, there were hundreds of analyses of wheat samples which showed a beautiful consistency and orderly relationship which led to the belief in 1940 that the riboflavin content of whole wheat was about one milligram per pound and that it often rose to 1.2 milligrams or higher. The figure of 1.2 milligrams per pound was chosen as the amount ideal enriched flour should contain. But as time went on, the chemists agreed one by one that all those beautiful analyses were about twice too high. There was a systematic error due to foreign colored substances that affected all the analyses approximately alike. It is now known that whole wheat contains only 0.5 milligram of riboflavin per pound.[15] Whether this sort of error has crept into analysis of other foods and distorted ideas of the human requirement for riboflavin there is not yet complete surety. Many of the older riboflavin analyses were made by the rat growth method which is free from this error but is subject to other somewhat lesser errors.

As regards niacin, the situation was even more muddled. There had existed for some time fairly satisfactory methods for the determination of niacin in lean meat products, but the application of these methods to cereals had given extravagantly high results. These results were entirely discredited by the fact that diets of a sort known to have produced pellagra contained according to this method of analysis enough niacin to prevent any such occurrence. At the time of the flour hearings in November 1940, these analyses were so thoroughly discredited that it was assumed there was virtually no niacin in such a product as ordinary white flour. By the time of the bread hearings, however, certain microbiological methods of assaying for niacin had been sufficiently applied to suggest that white flour often contains as much as 5 milligrams of niacin per pound. Because of this ambiguity of findings the quantitative human need for niacin was still very doubtful. However, the minimum of 6 milligrams first prescribed in the enriched flour standard was obviously too low for the purpose of preventing pellagra in people living largely on biscuits and fat pork. This led to a later recommendation of a minimum of 16 milligrams of niacin per pound of flour and a minimum of 10 milligrams of niacin per pound of bread, a recommendation which has been confirmed by later experience.

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[15] R. T. Conner and G. J. Straub. Cereal Chemistry 18: 671, (1941).

Recognition of the need for better analytical methods was one of the important results of the first bread hearing. During the year which followed committees were organized by the Association of Cereal Chemists and by the American Institute of Baking and their work was coordinated under the auspices of Research Corporation with a view to devising satisfactory methods. By extensive exchange of samples among the collaborating laboratories betterments were given thorough trials. By early in 1942 good agreement could be obtained on thiamine analyses[16] and great progress had been made with riboflavin and niacin.

A suitable chemical method for niacin analysis was slow in developing and for some time chief reliance had to be placed on a microbiological method. However, since bakery and flour mill laboratories do not have staffs familiar with bacteriological techniques, chemical methods were much preferred. During the past year or so chemical methods of fair reliability have become available, though some authorities still prefer microbiological procedures.[17] The essential difficulty in the earlier chemical analyses which had given such misleading results with cereals was the failure to eliminate extraneous coloring matters which intensified the color by which the niacin content was judged. By the use of suitable absorptions and elutions the niacin can now be fairly effectively separated from these coloring substances and then determined with fair accuracy.

Riboflavin work dragged more slowly, partly because there was less urge for a good analytical method owing to the fact that the riboflavin requirement for enriched flour (and by implication for bread) had to be repeatedly postponed for lack of a commercial supply of riboflavin for enrichment purposes. Some fifty or more laboratories worked together on the analytical problem before a satisfactory method was developed. Both chemical and microbiological methods are now in use.[18] In spite of the discovery of the earlier error in riboflavin assays, no change was made in the final requirement for riboflavin in enriched flour in the new standard. It remained at a minimum of 1.2 milligrams per pound, purely on the ground that ariboflavinosis is widely prevalent (though infrequently severe). There are large areas of the country, especially in the South, where milk consumption is low and it is here that bakery bread is least used. A high riboflavin content in flour was deemed advisable for these areas as without milk the diet is extremely likely to be deficient in this nutrient. More recent clinical experience has led to the belief that minor degrees of riboflavin deficiency are to be found in a significant proportion of the inhabitants of the northern states. Some witnesses registered objection to requiring more riboflavin in enriched flour than can possibly be derived from the wheat but this view was overruled.

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[16] D. J. Hennessy, Standard Thiochrome Assay for the Determination of Thiamine in Cereal Products. Charles N. Frey and D. J. Hennessy, Comparative Study of Methods for the Estimation of Vitamin B_1. Cereal Chemists Bulletin, 2: (2), May, 1942.

[17] Daniel Melnick, Collaborative Study of the Applicability of Microbiological and Chemical Methods to the Determination of Niacin in Cereal Products. Cereal Chemistry, 19: 553, (1942).

[18] John S. Andrews, Collaborative Study of Riboflavin Assay Methods (microbiological and fluorometric). Cereal Chemistry, 20: 3-23, (1943).

It will be recalled that at the first flour hearings much of the testimony was aimed at providing an enriched flour, the equivalent, so far as the commercially available synthetic nutrients were concerned, of old-fashioned water-ground flour. This grew largely out of the evidence presented by Drummond[19] and others that the vitamin B_1 intake of Anglo-Saxon population was much higher a hundred years ago than it is today. There was a tendency to assume that vitamin B complex deficiency did not occur to any appreciable extent at that time. However, on reflection, it was evident that the deficiency would not have been recognized unless it had occurred in severe form. Accordingly, there seemed better ground for enriching to whole wheat levels rather than to the less adequate and somewhat indefinite levels of old-fashioned flour. In the early months of 1941, extensive discussions of the general philosophy of enrichment had developed in the Food and Nutrition Board a preponderance of opinion favoring more ample enrichment. This seemed abundantly justified, not only by the historical considerations mentioned above, but also in view of the fact that we have other large sources of carbohydrates in our dietary which were not, and may never be, enriched. Most important of these is sugar, which is consumed in the United States to the extent of 100 pounds per capita per annum, as compared with 155 pounds of flour. The enrichment of sugar was discussed in the early months of the Food and Nutrition Board's existence but sentiment against it promptly developed, largely on the ground that the vitaminization of sugar might well lead to its consumption in increased quantities. Other carbohydrate products for which enrichment was not then provided, nor definitely in prospect, are white rice, corn meal and other corn cereal foods, macaroni and spaghetti. Each of these is a staple of importance for certain segments of the population and its use as such contributes toward thiamine shortage.

In accordance with this idea, a thiamine level of 1.1 milligrams per pound was recommended for bread, corresponding to a level of 2 milligrams per pound for enriched flour. This figure for flour is somewhat lower than the thiamine content of whole hard wheats generally used for making yeast raised breads, but is rather higher than that of the soft wheats which are used for home baked biscuits in the South.

The original decision to include iron among the nutrients in enriched flour was based on widespread recognition of extensive iron-deficiency anemia, and on the fact that whole wheat was a good food source of this mineral and white flour was poor in it. The minimal level recommended as a requirement in the standards first established was set low (6 milligrams per pound of flour, 4 milligrams per pound of bread). This was owing to anxiety on the part of milling chemists lest higher contents might provoke detrimental abnormalities in flour and bread. It later developed that plain white flour and especially white bread contained iron in amounts not much less than those suggested for enriched flour and bread. This was owing largely to a pickup of iron by the flour and bread in the processes of milling and baking, from contact with machinery and utensils made of iron. In order to effect the original intention of increasing the iron content of the diet, it was decided when the standards were revised to raise the requirement of iron for flour from 6 milligrams to 13 milligrams per pound and that of bread from 4 milligrams to 8 milligrams. This change had the further advantage of bringing enriched flour and bread into closer conformity with whole wheat products in respect to iron. Millers and bakers, in the meantime, had discovered that iron in the form of reduced iron (ferrum reductum) or as sodium iron pyrophosphate could be added in larger amounts without damage to their products.

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[19] A. Z. Baker, M. D. Wright, J. C. Drummond: Nutritive Value of Bread. Journal of the Society of Chemical Industry, 56: 191-T (1939).

It will be observed that the difference between maximum and minimum for each nutrient (with the exception of riboflavin in bread) is much smaller in the new standard than in the old. Practical experience had shown that the baker and miller could hold to narrower limits than was earlier thought technically possible. Accordingly, the limits were narrowed to discourage competitive advertising on the basis of a higher vitamin content in one producer's product compared with that of another. This helps to give the term "enriched" a single explicit meaning.

All of the foregoing recommendations for nutrient levels in enriched flour and bread depend for their validity, at least in part, on what human needs for each nutrient really are. This is difficult to determine. It is the special task of a Committee on Recommended Dietary Allowances to study this subject continuously. The latest recommendations of this Committee, approved by the Food and Nutrition Board, are given in Appendix C, page 118. Revisions can be expected from time to time. The reader should note that the recommended allowances are quite different from the minimum daily requirements fixed by the Food and Drug Administration and often referred to on labels of foods. The latter are lower and represent absolute necessity for the average person; the allowances are designed as goals for application to the population as a whole and insomuch as the requirements of a proportion of the population can be expected to exceed those of the average person a safety factor was included.

The Food and Drug Administration has all along regarded it as a principle of cardinal importance that the term "enriched" as applied to flour should be consistent with the term as applied to bread. In other words, it was held that the standard for enriched bread should be such that its requirements could be met by the use of enriched flour under customary intelligent bakery practices, without further fortification. "Enriched" would thus acquire a single definite meaning intelligible to the lay public. This was emphasized at the hearings.

Illustrative of the technical problems arising from law enforcement is that of the definition of bread. The nutritionists who testified soon found that their several ideas of what constitutes bread were vague, or at variance with one another. In 1936 the Food Standards Committee, a voluntary association of Federal and State officials, defined bread as follows:[20]

> "1. BREAD. The product made by baking a dough consisting of a leavened or unleavened mixture of ground grain and/or other edible farinaceous substance, with water, and with or without the addition of other edible substances.
>
> "2. WHITE BREAD. The product, in the form of loaves or smaller units, obtained by baking a leavened and kneaded mixture of flour, water, salt, and yeast, with or without edible fat or oil, milk or a milk product, sugar and/or other fermentable carbohydrate substances. It may also contain diastatic and/or proteolytic ferments and such minute amounts of unobjectionable salts as serve solely as yeast nutrients. The flour ingredient may include not more than 8 percent of other edible farinaceous substance. White bread contains, 1 hour or more after baking, not more than 38 percent of moisture. The name 'bread' unqualified is commonly understood to mean white bread."

It is to be noted that under this definition the components of bread do not include eggs; presumably the presence of eggs distinguishes cake from bread. Also, it is to be noted that bread is a baked product. Accordingly, the doughnut, a fried product, is not bread under this definition. A great variety of such fine distinctions is necessary under any form of administrative regulation.

The enrichment levels for bread are lower than those for flour because bread contains more moisture as well as several non-flour ingredients. The maximum allowable moisture in commercial bread is 38 percent. The usual moisture content of flour is 13 percent. White bread includes two popular varieties: the pan breads, which usually contain milk solids in some form, and the so-called hearth breads, of which the French and Italian types are the most important examples. The two formulas which follow represent two typical contrasting examples. Slightly leaner or richer formulas are used by a few bakers and intermediate ones by many.

BREAD FORMULAS OF TWO CONTRASTING TYPES

I	II	
Weight of Ingredients	Weight of Ingredients	
100 lbs. flour	100 lbs. flour	64 lbs. water
60 lbs. water	2 lbs. salt	2 lbs. yeast
2 lbs. salt	6 lbs. sugar	4 lbs. shortening
2 lbs. yeast	6 lbs. dried skim milk	¼ lb. dry malt
3 lbs. sugar	¼ lb. dough conditioner	¼ lb. mold inhibiter
3 lbs. shortening		
¼ lb. dough conditioner		184¾ lbs.
170¼ lbs.		

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[20] Food and Drug Administration, Service and Regulatory Announcements, Definitions and Standards for Food Products for Use in Enforcing the Food and Drugs Act, issued November, 1936.

Formula I will yield about 150 pounds of bread of 38 percent moisture content. The flour used equals about 66 percent of the fresh weight of the resulting bread. Formula II will yield about 161 pounds of bread of about the same moisture content. In this case the flour used equals 62 percent of the weight of the resulting bread. For a median case, about 64 percent of the weight of the bread can be taken as the weight of flour used. Accordingly, the enriching nutrients required in enriched bread are, in general, roughly 64 percent of those required in enriched flour. An exception will be noted in the case of thiamine.

It was made clear even at the earlier bread hearings that there was a decline in the thiamine content of bread during baking. The loss occurs predominantly in the crust and consequently tends to be greater in small loaves than in large and still greater in rolls and especially in hard rolls. The time and temperature of baking determine the loss. In the usual-sized loaves the losses range as high as 22 percent, but average about 10 or 12 percent. The loss was shown to be dependent in part on the character of the oven in which the baking was done. An allowance for this loss was reflected in the minimum standard of 1.1 milligrams per pound set for enriched bread, in comparison with 2.0 milligrams per pound recommended at these hearings for enriched flour. At the median figure of 64 percent flour in bread, and disregarding other sources of thiamine, a pound loaf of bread made with enriched flour should contain 1.28 milligrams of thiamine, instead of 1.1 as called for in the proposed order. The difference represents allowance for baking loss.

Another question which arose early was that of the extension of enrichment to bakery goods other than bread. Cakes, pies, pastries, and doughnuts came in for consideration. Naturally, many bakers desired to extend the practice of enrichment to these products and thereby to gain for them the anticipated public favor. However, among nutritionists the sentiment had developed that enrichment should not be extended to such products since they are not staples and are not consumed in uniform or nearly uniform quantities by the various elements of the population. It was felt that the benefits to be derived from their enrichment would be outweighed by the objectionable sales propaganda which might result. However, there is more recently a growing dissenting opinion on this point in view of the extensive use of sweet goods for quick lunches.

As regards riboflavin, a confusing issue arose from the fact that nonfat dry milk solids had long been used in bread in varying proportions, according to the type of the bread and the preference of the baker. There was no standard amount in use, yet the amount used largely determined the riboflavin content of the bread, as skim milk is a rich source of this nutrient. Some believed that the standard for bread should include as a requirement only the riboflavin derivable from enriched flour. Others held that the requirement for riboflavin implied by the enriched flour formula should be superimposed on that which would be furnished by some fixed and widely used proportion of nonfat dry milk solids. The latter witnesses questioned whether bread could properly be called "enriched" if it contained no more riboflavin than some bread containing substantial amounts of nonfat dry milk solids previously sold as unenriched. The upshot of the matter was that the proposed order for enriched bread required a minimum of .7 milligram per pound, which is nearly the amount of riboflavin which could be derived either from 6 percent nonfat dry milk solids or from the use of enriched flour. A maximum of 1.6 milligrams of riboflavin per pound of bread was allowed, in order to permit the baker to use both enriched flour and 6 to 8 percent of nonfat dry milk solids. No uniquely correct answer to the dilemma was possible. The result is merely a practical compromise.

Actually, most bakers prefer to use substantial amounts of nonfat dry milk solids as they contribute color to the crust and softness of texture to the crumb and prevent rapid staling. It is fortunate that this is so, as the use of skim milk powder in bread contributes importantly to its nutritional quality. Chief among the nutrients which it supplies are riboflavin, calcium, and a quality of protein superior to that of the cereal grains. Nonfat dry milk solids go far to make bread a suitable mainstay for those who must feed themselves at minimum cost. The Board has no wish to encourage increased bread consumption at the expense of other foods, but recognizes that economics will continue to exert a pressure on some people in that direction. Yet the bulk of the people are not forced to rely mainly on bread and each has his food preferences which are potent factors in his choice. For example, there are the so-called "hearth" breads which are extremely popular and which, in combination with the other foodstuffs of the usual dietary, are entirely wholesome, even though less nutritionally adequate in themselves. One cannot wisely restrict the variety of foodstuffs available to the people at large solely because certain components of the population would thereby be protected from some of the deficiencies to which they are subject.

Various philosophies on enrichment of foodstuffs were aired at the bread hearings. Sentiment had arisen in favor of confining the term "enriched" strictly to flour and bread and closely analogous products. Fear was expressed that otherwise all our foodstuffs would presently come to be "enriched" in heterogeneous fashion suitable for sales promotion purposes. While it clearly might be impossible under the law to prevent the addition of reasonable kinds and quantities of synthetic vitamins to foodstuffs which are not peculiarly adapted for correction of mass dietary deficiencies, the Food and Nutrition Board did not propose to lend itself to propaganda which might make an exaggerated virtue out of the addition of a vitamin or two to some article legitimately and profitably sold in an attractive package but inconsequential in its effects on the overall diet of the people.

A feature of the enrichment program which has occasioned considerable criticism on the part of leaders in nutrition is its failure to provide for the sale of so-called "mixed breads," under the term "enriched." Mixed breads include breads made with varying proportions of whole wheat and white flour (Chapter VIII, page 4) and also most of the so-called "rye bread," which consists usually of about 70 percent of white wheat flour and 30 percent of rye flour. Nutritionally, it is of obvious advantage to have all such mixed breads conform in their content of nutrients to the standard for enriched bread and there is no legal obstacle to such conformance. Producers of mixed breads must label them to indicate that their white flour component is enriched flour or that the breads have been enriched in the dough stage to conform to the levels of required nutrients prescribed for enriched bread, if such is the case. They may not, however, designate such mixed breads as "enriched bread" for shipment in interstate commerce. This is regarded as a hardship because the name "enriched" has acquired a sales value not realized in a more elaborate label statement. However, a descriptive name revealing the nature of its ingredients may be used.

It will be recalled that the term "flour" when unmodified means white flour under the Food, Drug, and Cosmetic Act. Likewise, bread unmodified means white bread. No whole wheat flour can therefore conform to the federal definition of flour with respect to ash content and mixed bread does not conform to the federal definition of bread. One can readily understand the impatience of laymen with respect to the restrictive effect of legal terminology, especially when it stands in the way of achieving a meritorious result. Some bakers would like to be free to label their mixed breads enriched and avoid an involved statement conveying the idea of enrichment with respect to its white flour component alone. An obstacle to doing so is found in the connotation of the word "enriched," which implies addition of ingredients not otherwise expected to be present. It would obviously be confusing and misleading to refer to whole wheat bread as "enriched" when the baker merely wishes to convey the idea that he is guaranteeing the levels of certain nutrients to be those usually found in whole wheat. For the same reason, though in less degree, it is confusing and misleading to refer to mixed breads as enriched when only one farinaceous component is enriched and the other is whole wheat or rye in its natural state, not artificially enriched. Many efforts have been made to find a solution to this dilemma so that all breads, whether whole wheat, white, or mixed, might bear a convenient form of label to indicate that they meet a common standard with respect to certain nutrient levels, but this will apparently require the substitution of some other term for "enriched."

CHAPTER V

MILLING AND BAKING INDUSTRIES AND THEIR SUPPORT OF ENRICHMENT

The introduction of enrichment of bread and flour would not have been possible without the cordial support of the majority of millers and bakers. It is therefore of interest to consider the nature of the two industries and to note the similarities and contrasts between them. An understanding of the two businesses facilitates an appreciation of the industrial interest in the matter and the scope of production which is affected by enrichment. It will be appropriate and useful also to acknowledge the official support which has been rendered by the organizations of the two industries and to indicate sources of further information which may be required.

THE FLOUR MILLING INDUSTRY

It is estimated that there are not in excess of 1,600 producing flour mills at the present time, though estimates of as high as 2,500 were made a few years ago. Of these not over 400 make shipments in carload lots. Perhaps 100 additional mills ship flour across state boundaries by rail or truck, leaving perhaps 1,100 which do only an intrastate business. However, by far the greater part of the total flour production moves in interstate commerce at one stage or another of merchandizing. This is especially true of bakery flour, nearly all of which traverses one or more state boundaries before being converted into bread.

While wheat is often classified into various types, the principal distinction of significance relative to enrichment is that between soft and hard wheats. The former is lower in the protein which gives tenacity to doughs. It is accordingly less well adapted to the production of yeast raised bakery goods but is preferred for biscuit and cake flours in which tenderness of the baked crumb is greatly prized. Soft wheat flour is therefore pre-eminently the family flour of our South. A large part of the wheat grown outside the great centers of wheat production in the Middle- and Northwest is soft wheat. Soft wheat is a crop of some importance in almost every state east of the Mississippi except those which border on the Gulf of Mexico. It also extends into the Southwest except in the more arid regions.

Hard wheat on the other hand is the great bread wheat and the product of the principal wheat producing areas. Its high gluten content renders its doughs capable of holding large volumes of carbon dioxide generated by yeast, thus producing a loaf of large volume and of fine porous texture.

While subject to variation from year to year, according to relative production, wheat prices and variations in quality as affected by weather conditions, about one-third of the flour produced in the United States is of soft wheat and two-thirds is of hard. Exact statistics are unavailable. Considerable amounts of soft and hard wheats are blended together for milling.

Important hard wheat milling centers are in Buffalo, Minneapolis, and Kansas City; soft wheat milling centers in Kentucky, Tennessee, and North Carolina. However, both soft and hard wheat flour milling is fairly widely disseminated elsewhere.

From the standpoint of composition, one of the most important differences between soft and hard wheat is that the latter tends to be higher in thiamine. The thiamine content of both kinds of wheat appears to be affected to some degree by climatic, geographic, and soil conditions, so there is some overlapping of thiamine values in the lower range of the hard and the upper range of soft wheats. The difference in median thiamine level in the two kinds of wheat is of importance from the standpoint of the possibility of improvement by retention of the vitamin contents of flour. Commercial white flours, unenriched, do not differ appreciably in thiamine content, whether made of hard or soft wheats.

Flour used in the United States may be classified as to destination. The following approximate estimates for 1943 reflect present trends:

	Cwts.
Bakery flour	102,000,000
Semolina and Durum [1]	10,000,000
Biscuits, crackers, pretzels	16,000,000
Family flour	65,000,000
Institutions (1941)	30,000,000

[1] Chiefly destined for macaroni, etc.

Total production of flour now is at least 10 percent higher than in recent pre-war years. Present export figures and those on the present consumption of flour by institutions in the United States are unavailable for publication because of security restrictions.

For several years prior to 1941 the volume of bakery flour only slightly exceeded that of family flour, but during the war years there has been a sharp rise of the former and a corresponding decline of the latter. Important features of the family flour trade are self-rising flour and phosphated flour. Self-rising flour is prepared primarily for making hot biscuits so popular in the southern states. Sodium bicarbonate and calcium acid phosphate are incorporated directly in the flour in proper proportions to furnish the appropriate leavening. The annual volume of self-rising flour is estimated at 18,000,000 cwts. but this figure may be somewhat too high, in view of the recent declining tendency of total family flour.

Phosphated flour, that is, flour to which calcium acid phosphate alone is added, is also produced in large volume, estimated at 14,000,000 cwt. with the same qualification as in the case of self-rising flour. Phosphated flour is used for making biscuit with soda and sour milk or baking powder. If soda is used, the phosphate serves the useful purpose of ensuring the presence of ample acid constituent. Both self-rising and phosphated flours go very largely into the southern market. Their use there makes two valuable contributions to nutrition: it increases the calcium intake in areas where low milk consumption tends to provide an inadequate margin of calcium; it also tends to protect thiamine from destruction during the baking of biscuit.

If the proportion of soda to acid is slightly too high the thiamine loss during baking may be 50 percent. Correct adjustment of soda to acid ratio will under the same conditions reduce this loss to about 10 percent. The manufacturers of leavening mixtures for self-rising flours, since the advent of enrichment, are well aware of this fact. They have studied it carefully and made suitable adjustments of their mixes. Since factory controlled adjustments are more likely to be correct than kitchen practice with soda and sour milk, the use of the pre-leavened flour is distinctly advantageous from a nutritional standpoint.

The most important trade association in the flour milling industry is the Millers' National Federation, 309 West Jackson Boulevard, Chicago 6, Illinois. It has 496 member companies, including nearly all the large and medium-sized milling concerns and a substantial representation of smaller firms. Subordinate to it is the Wheat Flour Institute which is equipped for experimentation in flour technology and especially in flour use. A prominent aim of the Institute is to disseminate as an educational service to the trade and to customers technical information concerning flour and its use. Messrs. Herman Steen and Herman Fakler, as vice-presidents of the Millers' National Federation, share the executive responsibilities. Mr. Fakler maintains his office in the National Press Building, Washington, D. C.

There are numerous state and regional associations in the industry, among which may be mentioned the following: Michigan State Millers' Association, Chelsea, Michigan; Southern Illinois Millers' Association, Sparta, Illinois; Associated Millers of Kansas Wheat, Kansas City, Missouri; Oklahoma Millers' Association, Oklahoma City, Oklahoma; North Pacific Millers' Association, Portland, Oregon; Ohio Millers' Association, Columbus, Ohio; Piedmont Millers' Association, Richmond, Virginia; Soft Wheat Millers' Association, Nashville, Tennessee.

The Millers' National Federation and several of the regional associations have given direct and continuing support to the enrichment program from its inception. Dr. W. H. Strowd, Secretary of the Soft Wheat Millers' Association, is particularly interested and qualified by technical training in the nutritional problems of the South. He promoted and introduced into wide trade practice "Bi-Capt Flour," which antedated "Enriched Flour" and was fortified with thiamine, niacin, calcium, and phosphorus. Officials of the Millers' National Federation have attended and testified at the flour hearings. They have also liberally responded to requests by the Food and Nutrition Board or its members for information and have arranged for numerous special meetings of millers to consider enrichment problems. At these, as well as at its regular annual meetings, representatives of the Board have been invited to speak to the Federation's members.

Since January 1941, the Wheat Flour Institute has published a special series of bulletins relating to enrichment. These have supplied the industry with detailed information on the progress of events in relation to enrichment. Technical information about enrichment requirements and procedures, about government regulations on labelling, about losses of vitamins in baking and during storage of flour, was also included. Much of the technical information was developed through the agency of the Technical Committee of the Federation. To the work of this committee the laboratories of leading milling firms and of allied trades liberally contributed the services of technical staffs on a cooperative basis.

Several of the promotional activities of the Millers' National Federation were undertaken in conjunction with baking industry organizations as noted in the latter part of this chapter. Illustrative documents are shown in Appendix D.

THE BAKING INDUSTRY

Since the baking industry deals with a product which must be delivered fresh daily to the consumer, it is organized quite differently than the milling industry which vends a relatively stable product capable of being stored for weeks or months without deterioration. As regards the large component of the population which consumes flour largely in the form of bakery bread, the baker stands between the miller and the public. Baking establishments must be located relatively near their customers. It is accordingly not surprising that the total number of bakeries is at least ten-fold larger than the number of commercial mills. According to the United States Census figures of 1939, there were 18,043 baking establishments each producing products to the value of $5,000 or more annually. In addition it is estimated that there are 10,000 to 12,000 smaller bakeries in the United States.

Many bakeries are organized in extensive chains, each unit operating in its own geographical area. Some of the larger national chains are those of the Continental Baking Company, Ward Baking Co., General Baking Company, Purity Bakeries Corporation, Campbell Taggart and Associated Bakeries, and others whose business is largely or exclusively in baked goods. In many instances popular brand names are used throughout the chain or a large fraction of it. Brand names for bread are highly prized and some popular names are shared by arrangement by a number of affiliated firms each operating in an assigned area. In addition to these purely baking businesses there is a great deal of baking done by or for grocery chains. One of the largest baking businesses in the country is conducted by the Atlantic and Pacific Tea Company, an example followed by many other grocery chain establishments of regional or national scope. The American Bakers Association estimates that there are 5,000 to 7,000 wholesale and house to house delivery bakeries.

It is estimated that only about 10 percent of the country's bakery bread moves in interstate commerce.

The preference of the South for hot bread is a familiar fact. This preference extends more or less into neighboring territory, especially into those states to the west of the southern reaches of the Mississippi River. In order to bring out the contrast in bread habits, we shall include within the "hot bread belt" of the south the eleven states lying south of the Potomac and Ohio Rivers and east of the Mississippi. These states, according to the United

States Census of 1939, had a population of 25,910,512 out of a total of 131,669,275 for the continental United States. In these states the production (and approximate consumption) of yeast raised products was 1,015,962,000 pounds, or about 40 pounds per capita for that region, as compared with 90 pounds per capita for the rest of the country. It is in this region that the consumption of family flour runs high. Of white pan bakery bread this region produced 31 pounds per capita compared with 60 pounds for the rest of the country. The per capita consumption of bakery bread, of course, varies greatly from place to place, being highest in the cities and least in the country. The consumption of bakery bread is steadily rising in the South, especially in areas where urbanization and industrialization are in active progress. Southern consumption of bakery bread has risen more rapidly during the war years, partly because of the general growth of industry and partly because of increasing employment of housewives in war plants.

In the country as a whole 90 to 94 percent of bakery bread is white. Brown breads are made largely of mixtures of whole wheat and white flours. About 20 percent whole wheat is the most popular, though proportions commonly range from 10 to 40 percent. A fraction of 1 percent of bakery bread output is 100 percent whole wheat bread. Rye bread, so called, is usually made with 30 percent rye flour and 70 percent white wheat flour. The proportions and varieties of bread vary, of course, from one area to another.

Of the organizations of the baking industry, the American Bakers Association is the most influential, at least as regards the broader policies of the industry. Its membership includes 1,500 firms representing 1,840 plants. It was organized in 1897 as the National Association of Master Bakers and has its principal office at 1135 Fullerton Avenue, Chicago 14, Illinois.

The American Institute of Baking is a separate organization which, however, was established in 1919 by individuals who were prominent in the affairs of the American Bakers Association. An endowment fund organization known as the American Bakers Foundation was created in 1921 to promote education in relation to baking and the Institute of Baking has become its principal beneficiary and agency. The relationship of the Institute to the Association has been maintained throughout its history and the American Bakers Association has contributed largely to the financial support of the Institute until recently, when the Institute became self-sustaining through membership fees supplementing endowment income. The Board of Directors of the Institute includes fifteen persons, of whom eight are elected from the membership of the Board of Governors of the American Bakers Association. The Institute concerns itself with scientific, technical, and educational problems but not with trade policies. Its principal offices are at the same address, i.e., 1135 Fullerton Avenue, Chicago 14, Illinois. Its permanent Director is Dr. Franklin C. Bing.

A still larger bakers' organization in point of numbers is that known as the Associated Retail Bakers of America, which came into existence in 1918. Its Secretary is Mr. Frank J. Jungewaelter, who has his headquarters at the Chicago address mentioned above, indicating the close affiliation of this Association with the American Bakers Association. Its membership is 2,500 but it also has 4,200 additional affiliated members whose affiliation arises from their membership in various state associations through which the bulletins and other publications of the Asssociated Retail Bakers are circulated.

In addition to these there are 23 state and regional bakers' associations and 150 municipal or county associations.

All three of the above national organizations have lent active support to the enrichment program. At the annual bakers' convention on October 13-16, 1940, at which the three national organizations, as well as many of the local organizations were represented, the whole matter of enrichment was thoroughly discussed. The account of this session is contained in the November 1940 issue of the American Bakers Association Monthly Bulletin. At a meeting of the American Institute of Baking Directors on January 22, 1941, a resolution was passed formally supporting the proposed enrichment of bread. (See Appendix E.) Similar action was taken by the American Bakers Association Board of Governors on the following day. On February 17, 1941, the American Institute of Baking recommended that the American Bakers Association jointly with the Millers' National Federation and Associated Retail Bakers of America call an industry-wide conference to which all members of the baking and milling industries and allied trades should be invited. This conference was held in Chicago on March 5, 1941 and is reported in the American Bakers Association Monthly Bulletin of June, 1941. In January 1942 the American Bakers Association convention at Boston devoted an entire day to the discussion of the enrichment program, its problems and progress, and cordially recommended to its membership a fuller support than had previously been given it by some of its individual firms.

Similar supporting actions were again taken by the Board of Governors of the American Bakers Association in January 1943. Copies of all the principal resolutions and actions taken by the American Bakers Association and its allied organizations are shown in Appendix E. In addition to these formal actions, the American Bakers Association and the American Institute of Baking have been represented at all of the Federal Security Agency hearings on bread and on flour and have taken an active part in presenting testimony at the hearings which concerned bread. The organizations have also through their publications kept the industries fully informed with regard to the actions of the Food and Nutrition Board and of the Federal authorities with regard to the enrichment program.

Through the Institute of Baking there have been issued thousands of copies of the following pamphlets designed to inform the public on the enriched bread issue.

Putting Bakers' Bread in the Preferred Class
Question and Answers About Enriched Bread, 1941
Enriched Bread Facts for Physicians and Professional Workers, 1941
Enriched Bread and Flour from the Housewife's Viewpoint, 1942
Enriched White Bread, 1943
The Enrichment of Bread Is the Law of the Land, 1944

Together with the Millers' National Federation and the Associated Retail Bakers of America, the American Bakers Association contributed financially to the National Radio Program entitled "Listen America" under the supervision of the Office of Defense Health and Welfare Services of the United States Federal Security Agency. In addition, hundreds of bakers, large and small, carried on extensive magazine and newspaper advertising which contributed greatly to make the public aware of enrichment.

It is obvious that without this organized support on the part of the industry only a very meager success could have been achieved in the voluntary promotion of the enrichment program.

CHAPTER VI

ENRICHMENT IN FLOUR MILL AND BAKERY

Flour is for the most part enriched by the simple process of feeding continuously into the mill-stream an accurately controlled minor stream of an enrichment mixture. The enrichment mixture is prepared, for example, by mixing in a batch mixer 25 pounds of appropriate vitamin-mineral mixture, supplied by the manufacturer, with 375 pounds of dry patent flour. The resulting 400 pounds of "premix" fed at the rate of 8 ounces per hundredweight will enrich 800 hundredweight.

While feeder enrichment is the most popular for plain flour, it is less used for the production of enriched phosphated flour and enriched self-rising flour, both of which are extensively used in the South. These flours are enriched by adding the enriching ingredients to the flour along with the calcium phosphate or the leavening agent (calcium acid phosphate plus sodium bicarbonate) as the case may be, and mixing in a batch mixer in a single operation to uniformity. In neither type of enriching is unusual equipment required, as both feeders and batch mixers have long been in use in the industry.

Iron additions have presented a problem, as it is necessary to choose a form of iron which is both physiologically available and well adapted to admixture with the other ingredients and with flour, without introducing any special problems of discoloration or adverse chemical action. Iron reduced in hydrogen (ferrum reductum) has been much the most popular form of iron for this purpose. Sodium iron pyrophosphate is a more expensive competitor which has the added disadvantage of a lesser physiological availability. It possesses the greater merit of being light colored, which is of considerable advantage in the enrichment of corn grits where some portion of the enriching ingredients may appear on the surface. The gray color of reduced iron is, however, imperceptible in the enrichment of flour.

A further problem of some importance in connection with flour enrichment is the loss of thiamine activity during a long period of storage, especially in warm, humid weather. Loss of thiamine occurs under these circumstances amounting to 10 percent after a year's storage. Since the usual period of storage is only two or three months, the loss is negligible.

The definition of enriched flour provides for calcium and vitamin D additions as optional ingredients. The use of vitamin D has been extremely slight, but calcium appears as a component of a large volume of enriched phosphated flours and in all self-rising flours.

ENRICHMENT IN THE BAKERY

In the bakery enrichment is equally simple. In the course of making the dough in the usual way, the vitamin mineral mixture is added, preferably in solution or suspension in water or milk. The vitamin producers supply the mixture in the form of wafers, each of which contains all of the ingredients in amounts sufficient to enrich the bread to be produced from 100 pounds (or 50 pounds) of flour. The wafers are grooved to facilitate breaking into halves or quarters for the enrichment of smaller batches. This scheme works very well in most bakeries, though complications sometimes arise in the smaller ones. In certain types of dough-mixing operations and equipment the fluid ingredients of the bread are first mixed together and flour is then added to the desired stiffness of dough. This may result in a significant deviation in the quantity of flour going into the mixture. For these reasons many small bakers prefer to use enriched flour.

When the enrichment of flour was first formally proposed late in 1940 it was assumed by many not associated with industry that enrichment of flour would take care of enrichment of bread. However, Standard Brands, Incorporated, a leading distributor of yeast, had developed a high vitamin yeast in 1938 which was in use in the baking industry and which could be used readily in conjunction with plain flour for the production of enriched bread. They advocated the use of this high B_1 yeast with 6 percent dry milk. Partly because there was a slight cost advantage to the baker in paying for enrichment ingredients in the form of yeast, and partly because the yeast companies were prepared to render extensive advice and technical service to the bakers in connection with enrichment, enrichment by yeast soon took the lead.

During 1941 and 1942 it was estimated that four-fifths of the bread being enriched utilized yeast as the source of the ingredients. The remaining one-fifth was enriched by means of suitable vitamin mixtures, usually in the form of wafers, supplied by the distributors of enriching ingredients. An almost negligible proportion of bread was made from enriched flour. When, however, the Food Distribution Order requiring the enrichment of all bread went into effect early in January 1943, a certain number of the smaller bakers found it more convenient to use enriched flour than to exercise the necessary controls for the practice of enrichment by other means in the bakeries.

It has been a matter of some surprise that the use of enriched flour in bakeries has been so small. It is now, however, definitely on the increase and may in the future become more important than at present. It is easy to understand why the use of high vitamin yeast was popular with the bakers as it did not involve the addition of any new or strange ingredients, but it is not so easy to understand why bakers should at the beginning have preferred to use enrichment tablets rather than enriched flour. Among the factors favoring this practice was the consideration that the baker could, when enriching his doughs, make proper allowance for the vitamin contributions which he derived from any other ingredients. Defatted milk solids can furnish measurable amounts of thiamine; still larger proportions of the total thiamine may come from flour, depending upon the grade of flour used. Bakers using short patents would have to add larger proportions of the enriching ingredients than those using straight flours. Any economies so effected are reflected in the bakers' costs.

In the early months of the program many bakers felt that the addition of thiamine alone gave them most of the sales advantage that they could get by more complete enrichment, and some bread was sold which was labelled as being enriched with vitamin B_1 only. Some bakers had built up popular local trade in bread containing wheat germ or similar additions and they did not wish to disturb this market by radical modifications of their formulas, but they did wish to gain the additional advantage of conforming to enrichment requirements as to composition. As time has passed these irregular modes of enrichment have tended to decline, but the baker in general still favors doing the enriching for himself.

It will be recalled that the first flour standards issued May 26, 1941, included riboflavin as a required ingredient, but this requirement was abated pending the availability of an adequate commercial supply of the vitamin. After several postponements the requirement was finally announced to take effect October 1, 1943, by which time it was evident that a fairly adequate supply would certainly be available. As this effective date approached, the yeast companies were faced with the problem of putting out a modified form of high vitamin yeast containing adequate riboflavin to meet the riboflavin requirement for enriched bread when the yeast was used in customary proportions. This proved to be so inconvenient and uneconomical that many of the major yeast companies ceased to promote the use of high vitamin yeast.

If yeast is grown in a medium containing an ample amount of thiamine or the thiazole and pyrimidine components necessary for its synthesis, the yeast avidly seizes and incorporates within its cells nearly all of the vitamin or its components which are available. Consequently, very small amounts remain to be discarded with the waste liquor. Yeast does not exhibit any similar avidity for riboflavin and the losses of this vitamin in the waste liquor are excessive from a cost standpoint. This fact, plus the problem of color in yeast when riboflavin is used, largely accounts for the decline in popularity of high vitamin yeast in the riboflavin era. Some of the leading yeast firms, which have been very ardent and influential in promoting the practice of enrichment, have increasingly supplied to their customers, instead of special yeast, enrichment tablets of suitable proportions to be introduced into the doughs along with the ordinary yeast. This is very fortunate as the promotional activities of such yeast companies through their wide-spread sales agencies have been major factors in bringing about the successful introduction of enrichment into bakeries.

MILK IN BREAD

Once riboflavin came into view as an actual required ingredient, a further circumstance favoring enrichment in the bakery was the variable use of milk products, all of which are naturally rich sources of riboflavin. If the baker uses enriched flour and also includes nonfat dry milk solids in his dough, he comes out with a bread exceeding the required minimum of riboflavin by an amount proportionate to the milk used. The bread has cost him more to produce than if he himself added the amount of riboflavin called for by the standards. Distributors of enrichment wafers for the use of bakers have met the situation by preparing distinctive tablets of specified riboflavin content adjusted to the baker's intentions as to the proportion of milk solids to be used.

Leaders in the baking industry consider the enrichment of bread to be the second in point of time of two fundamental contributions to the nutritional improvement of its product, the first being the widespread use of milk in the making of bread. As long ago as September 1923, in an address before the American Bakers Association, Professor E. V. McCollum stated:

> "So far as we now know, the simplest, cheapest and most effective way to improve the quality of bread is to introduce more milk solids in its composition. This improvement of the bread supply is sound from the physiological, agricultural, and economical standpoint, as well as being sound in that it does not run counter to our established dietary habits."[21]

It is interesting to note that in his address on this occasion, Professor McCollum also commented that no return to whole wheat flour seems to be possible, that the white flour industry is here to stay. The use of milk products in the commercial production of bread is primarily a development of American industry, for it is not the ordinary practice in European countries or elsewhere to use much milk in this manner. Even in the United States it has not been customary to include milk in the dough formulas for making hearth type breads such as Vienna, French, or Italian breads, because the inclusion of the milk alters the character of the crust, nor has it been generally customary to include milk in the production of whole wheat bread, because the characteristic wheaty flavor is thereby altered. However, the use of milk in these types of bread has been increasing within recent years, a highly desirable trend from the nutritional point of view.

There is no need to discuss the wealth of experimental evidence showing the nutritional value of milk additions to bread. The nonfat milk solids commonly used contribute importantly to the quality of the protein mixture and they increase the quantity of protein as well. Calcium, riboflavin, and all the other important nutritional substances supplied by nonfat milk solids likewise are increased in direct proportion to the amounts of milk used. Feeding experiments with bread made according to commercial formulas repeatedly have demonstrated the superiority of bread made with milk over bread not so made.

From the point of view of the effect of milk on the technology of bread production, it may be mentioned that there is convincing evidence that the finished loaf of bread is in every measurable way a more palatable loaf when it contains milk. The crust of the loaf has a more agreeable color, the inside of the loaf or the crumb, a softer texture, and the entire loaf has a better shape. The bread tends to retain its moisture more tenaciously and so remain fresh longer. Toast made from bread which contains milk is considered to be of superior flavor. It has also been shown experimentally that consumers prefer bread made with milk over bread not containing milk.

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[21] E. V. McCollum: The Bread of Life. Baking Technology, 2: 268-273 (1923).

Because of the desire of the baking industry for an economical and reliable source of milk suitable for baking purposes, the dry skim milk industry has been developed. Under ordinary circumstances about 400,000,000 pounds of nonfat dry milk solids are produced annually, and about half of this quantity is used by the baking industry, largely in the baking of bread. In addition to nonfat dry milk solids, other milk preparations are used to an appreciable extent, such as evaporated milk, evaporated skim milk, and fresh milk from which the cream has been removed. The tendency of the industry has been to include six parts of milk solids to every one hundred parts of flour in the formula; this proportion conveys to the finished loaf of bread approximately the same amount of nonfat dry milk solids as would be the case if all the liquid in the dough were fresh skim milk.

During the war a considerable shortage of nonfat dry milk solids occurred because of very large shipments on Lend Lease, especially to England. The supply available to the baking industry was greatly curtailed and it could not be made up entirely by the greater use of other forms of milk. In order to conserve the available supply, War Food Order No. 1 limited the amount of milk which could be included in any baker's formula for bread but it required the use of 3 percent in all white pan bread until such supplies became inadequate. (See page 51.) The baking industry requested government agencies to make more milk available at the earliest opportunity, and the Food and Nutrition Board repeatedly called attention to the desirability from the nutritional point of view of the inclusion of more milk in bread. (See page 112.) Fortunately the restriction was lifted in August 1944 because of the increased supply of roller process skim milk solids for civilian use. By returning to the normal formula calling for 6 percent of the weight of the flour as nonfat dry milk solids, the baker in most cases is not obliged to add much riboflavin to meet the standards for this particular ingredient of enriched bread.

Statistics on the use within recent years of milk products by the baking industry are difficult to obtain, the best estimates being those of the War Food Administration. According to available information, the baking industry made use of the following amounts of milk products in 1942 and 1943:

ESTIMATED AMOUNTS OF MILK PRODUCTS CONSUMED IN THE MANUFACTURE OF BAKERY GOODS

	1942 Millions of pounds	1943 Millions of pounds
Dried skim and whole milk	180	170
Condensed skim milk, sweetened condensed whole and skim milk	185	295
Fluid milk	150	75
Total (as dried milk products)	246	258

During 1941 it was estimated that a little less than 200,000,000 pounds of dried skim milk was used by the baking industry. It is of interest to note that the total amount of milk solids used by the baking industry was not materially lessened by the restrictions initiated late in the year of 1943 in the sales of dried skim milk for civilian uses resulting from an order of the War Food Administration, because of the greater use of other forms of this nutritionally important ingredient of bread. In 1944, bakers were obliged to rely increasingly on fresh whole milk, fresh skim milk, sweetened condensed milk, and sweetened condensed skim milk for the milk solids other than butterfat which have come to be considered as normal ingredients of white bread. One baker, for example, reported that in a three-month period in 1942 he used 22,322 pounds of skim milk powder. For a similar three-month period in 1944 in which more bread was produced, he was only able to obtain 3,215 pounds of skim milk powder, but he also used 12,220 pounds of whole milk powder, 2,037 pounds of condensed skim milk, and 894 pounds of sweetened condensed milk. "This has made a difficult condition for us," he wrote, "because the use of these more expensive milks has thrown our costs away out of line for the first three months of this year." This increased cost to the baker is understandable when it is remembered that the baker is seeking the milk solids other than fat, and all milk products other than skim milk powder are relatively expensive, thus resulting in a general increase in cost of production.

The possibility of substitutes has been examined, but although whey powder, soy bean flour, and other preparations convey certain physical characteristics to the finished loaf of bread, they do not entirely replace milk from the viewpoint of its beneficial effects on the palatability of the loaf, and of course they do not make up for the nutritional properties of skim milk solids. It was with considerable satisfaction therefore that the baking industry looked on the increased availability for civilian use of nonfat dry milk solids and the lifting of regulations on the amounts permitted in bread which were embodied in the order of the War Food Administration in August 1944. Further, the attitude of the industry definitely reveals that enrichment is not looked upon as a substitute for the use of milk products in the making of white bread. Each program, the use of milk and enrichment, is considered as a separate step in improving the nutritional value of bread, and each supplements the other.

ENRICHMENT IN THE MILL

From the standpoint of enforcement of enrichment standards, it would be of great advantage to have enrichment take place exclusively at the mill. There are far fewer mills (approximately 1,600) than there are bakeries (approximately 30,000) so that the number of establishments to be inspected would be greatly reduced. Also, since there are only a few hundred millers who ship in interstate commerce and since most bakery bread is made from flour which has crossed some state line, most of the enriched bread made from enriched flour would automatically reflect the influence of federal enforcement of enrichment standards. In addition, a large fraction of the flour now sold in unenriched form is used by hotels, restaurants, and public institutions, very few of which bother with the enrichment of the bread which they bake. It has proven difficult to enlist public eating places. While the housewife will look for the label "enriched" when she buys bread at a store for home use, nobody expects the roll or slice of bread served him in a restaurant to be labelled, and rarely thinks to ask if it is enriched. It usually is not. However, some public eating places use enriched bread and so indicate on their menu cards. This practice is to be further encouraged. (See Appendix C, page 117.)

Flour used in public institutions is also in need of more attention, although no systematic survey has been made of the use of enriched products in such establishments. We do know, however, that asylums, public hospitals for special classes of unfortunates, and often jails, are under considerable public pressure to keep their budgets low. Throughout the history of deficiency diseases, many of the severest epidemics have been recorded in asylums and reformatory institutions. A useful service can be rendered by state nutrition committees making specific inquiry on the practice of the enrichment program in such institutions within the borders of each state.

Whether enrichment is accomplished through the use of enriched flour or through the use of enrichment tablets or concentrates is of little importance. The important thing is that it be accomplished.

CHAPTER VII

PROGRESS UNDER VOLUNTARY ACTION

Immediately following the National Nutrition Conference in Washington, May 25-27, 1941, large firms of the baking and milling industries began to put enriched bread and enriched flour upon the market in considerable volume.

It was conspicuous that the practice of enrichment began in the field of quality goods. This was especially noticeable in the flour field, where the housewife has great faith in the label of some nationally advertised brand to which she has become accustomed. The more adequate her income, the more willing she is to pay an extra price for the product which she has tried with good results. Bread sells upon a more democratic basis. Often the same loaf goes into the homes of rich and poor alike in a given area. It was, nevertheless, true that bakers and millers catering to well-to-do trade were the first to take up enrichment. The quality products could better stand the price increment which the cost of enrichment involved. This, of course, is not entirely as the Food and Nutrition Board would wish it, for it is the low-income group which stands most in need of enrichment of its staples. However, it was recognized that this kind of a movement must start at the point of least resistance and grow as its merits are proved. In this case, growth from the top downward was to be expected and this is what has occurred. Growth downward has not yet extended as far as we wish.

A note of disappointment was expressed even at the Washington conference in 1941 at the relatively small emphasis which was then placed on the enrichment of bread and flour. Soft-pedaling of enrichment at that time was due in part to the feeling of many nutritionists that we should have undertaken the promotion of whole wheat bread instead. There was also some feeling that the use of synthetic vitamins in flour and bread would take on the character of a racket. Also it is probable that other food industries, jealous of the attention which the flour and bread enrichment program tended to focus upon these particular food products, brought some pressure to bear upon government agencies to diminish the emphasis which had earlier been suggested.

Nevertheless, the enrichment of white bread and flour started off at a level of about 30 to 35 percent of the entire output of these products. It must be confessed that the government leaders of the movement at first hoped it would grow by itself and that little help from the Board would be necessary. For several months the Board received without concern the hopeful but fragmentary reports flowing in from industry about the extent of enrichment in practice. During the autumn of 1941, however, several incidents occurred which forced the Board's more serious inquiry into the health of the infant undertaking. Several bakery chains which had early embarked upon enrichment measures were reported as having abandoned them. One bakery chain in particular tried the experiment of leaving the word "enriched" off its labels although it was said that the addition of enriching ingredients was continued as before. The purpose was to test the value of the label "enriched" as a sales stimulant. Apparently the first conclusion of this firm was adverse, for presently its bakery wagon drivers began defensively to pass out a story which incidentally injured the program a great deal. The story was that all white bread was now being enriched and, therefore, the firm had decided that it was no longer necessary to so label the bread. It may be remarked here that the widely prevalent idea that enrichment was already being required by the government has often been a deterrent to the program in many areas. Housewives neglected to ask for enriched bread or enriched flour on the assumption that all white bread was being enriched.

These untoward developments led, late in 1941, to a first-hand survey of the situation, especially in the South and in southwestern areas. A tour among the bakeries and mills of Kansas, Oklahoma, Texas, Louisiana, Mississippi, Tennessee, Alabama, Georgia, and the Carolinas in November and December, 1941, revealed a very unhealthy state of the program. Everywhere the millers and bakers criticized the government for having started a project and then having failed to support it. Undoubtedly millers and bakers had fondly expected such fostering by government as to relieve them of the need for strenuous effort. The conviction was general that people were not asking for enriched bread and flour and that enrichment was accordingly making no progress. The small price difference between unenriched and enriched grades of flour was sufficient to leave the enriched products growing stale on the grocer's shelves. The apparent price differential appeared exaggerated by reason of the fact that enrichment was largely confined to the brands which had always been higher priced because they were sold on a quality basis to a select trade, while the brands which had always been cheaper maintained their old prices because they were not enriched.

It is undoubtedly true that some state nutrition workers were giving very little support to the program at that time. Everybody appeared to be relying on someone else to do the work. There was a general belief (not justified by the facts) among teachers and leaders of nutrition that the baking and milling industries were making, or at least were destined to make, a profit from the enrichment program and should be left to bear the costs of promoting enrichment by advertising. There was no specific misinformation to this effect, merely the general suspicion that industry would not have undertaken it if it were not profitable.

A second factor in non-support of enrichment by disinterested nutritionists was a widespread conviction that whole wheat bread is still better than enriched, on account of the other B vitamins which occur in the bran and germ, as well as to some extent because of the superior proteins. From a purely scientific standpoint this may well be true in some degree, depending on the preponderance of grain in the dietary. The problem, however, was not a problem of abstract science but the very practical problem of persuading people to choose a more nutritious type of bread and flour. Very little information had as yet been distributed to the state and local supporters of the nutrition program regarding the difficulties which had been encountered elsewhere in persuading populations to change from white to dark flour and bread.

Another factor which tended to make such nutrition workers advocate whole wheat, in preference to enriched products, was their misconception that most of the brown breads on the market were whole wheat or near it. Actually, this has always been far from the truth. Most of the brown breads sold in any area in the country were, and still are, so-called mixed breads, made from a mixture of white and whole wheat flour or bran in varying proportions. Most popular of all are those which contain from 10 to 20 percent of whole wheat, though some range as high as 30 to 40 percent. A very small amount of 100 percent whole wheat bread is sold; not more than a fraction of 1 percent of the entire bread output. The use by bakeries of whole wheat flour, most of it in admixture with white flour, has never exceeded 2½ percent of the total of bakery flour. Even rye bread usually contains about 70 percent of white wheaten flour.

Owing to these causes and perhaps others, grocers generally experienced very little demand for the enriched products. Many a grocer visited at that time stated that he had never had a customer call for either one. Some of them claimed that they had called their customers' attention to the products but in vain. In general, very few posters or other promotional materials regarding enrichment were in evidence. The millers and bakers bitterly complained that the supporters of the national nutrition program were neglecting enrichment.

Another important deterrent to expansion of enrichment at that time was the delay on the part of the Armed Services in coming to a decision as to the use of enriched flour and bread in place of the ordinary products. The military authorities took the position that army and navy rations must be determined solely by considerations having to do with the efficiency of the forces. While sympathy and interest were expressed in improving the staples for the civilians, it was held that the military forces should not adopt enrichment merely as an example to them. Non-adoption by the Army and Navy was pointed to by reluctant industrialists as evidence of skepticism on the part of the government with regard to the value of enrichment and many millers and bakers were inclined to await evidence of a changing viewpoint before committing themselves. In view of the liberal and varied rations supplied to our armed forces, it was difficult to make out a case of necessity for the enrichment of the farinaceous component. However, as the vitamin content of the rations as actually served under field, ship, and camp conditions began to be studied, there was increasing concern about the extent of loss of vitamins in the process of cooking of foodstuffs. This was largely responsible for a gradual change of viewpoint of the military authorities and their ultimate decision to adopt enriched bread and flour. This came about in February 1942, just as the civilian enrichment program was passing its low point.

During the course of the tours above mentioned every possible effort was made to correct misunderstandings and abuses enroute by talking to groups of nutritionists when possible. It is felt, however, that the dismay occasioned by the unhappy state of the program made these persuasions less effective than they would have been under more optimistic circumstances. In restrospect, it now seems certain that the program would have died at that stage had not vigorous measures been taken to resuscitate it.

Upon completion of the survey active steps were taken to circulate, through the office of Defense Health and Welfare Services, a truer analysis of the situation and a plea that the state and local people should come to the support of enrichment. It was pointed out that many efforts had been made to sell whole wheat or long extraction products to the American public without success; that similar endeavors had been carried out in vain in other countries. Attention was also called to the fact that enrichment was costly to the bakers and millers and that it would be abandoned unless a public demand for the products was created. The baker selling enriched bread could only hope to get his additional costs back by expanding his sales, at the expense of some more backward baker who refused to adopt the practice. He had to advance his price a penny a loaf or not at all. A penny a loaf would have destroyed his trade so he absorbed the cost of enrichment. Without a public demand the progressive baker could not recoup his expenses and would be forced to abandon his venture. This had been so much the case throughout 1941 that the number of bakers who had given up enrichment completely counterbalanced all the new recruits who had been persuaded to try it by the promotional activity of the American Bakers Association and the American Institute of Baking.

In the case of flour, the situation was somewhat different in that it was possible for the miller to add his enrichment costs to the price of a bag of flour. These costs amounted to a few cents a bag, depending, of course, on the weight of the contents, but unless the public were educated to believe that the enrichment was worth the small extra price, the non-complying miller had every advantage in competition. These facts were set forth in letters, literature, and addresses to nutrition groups throughout the country as the new year began.

In response to this plea, the nutritionists rose nobly and with great effect. Their activities, supplemented by such effort as the members of the Food and Nutrition Board who were most responsible for this phase of the program could supply, were promptly reflected in a concrete demand in the grocery store. All over the country millers and bakers hastened to get on the band wagon. The favorable decision of the Army and Navy added an important impetus to the now rising sentiment in favor of the program. The fact that the military forces were contracting for considerable quantities of enriched flour at the time further brought the matter forcefully to the attention of many previously indifferent millers. Within the first six months of 1942 the extent of enrichment of white bread and family flour rose dramatically from a level of about 30 percent to 75 or 80 percent. It was difficult for us who had been so concerned about the outlook in the South to believe that such a transformation could take place. Since that time we have been able to consider the enrichment program well established in the sense that it is unlikely ever to be abandoned by the major and more progressive elements of either industry.

Much, however, remains to be done to give enrichment full effect. Except in those states which have adopted mandatory enrichment of white bread and flour, relatively little flour of the cheapest grades which go into the mouths of the most poorly fed is enriched. As long as this condition exists only a fraction of the benefits of total enrichment can be realized. The merit of the program from the standpoint of the well-to-do is small as compared with the potential benefits to low-income peoples, especially in hard times. While bakery bread shows no great contrasts of quality at extremes of income level, there are still thousands of small bakeries which, up to the end of 1942, paid no attention to enrichment. The over-all extent of bakery bread enrichment is gratifying, but it cannot be too strongly emphasized that nobody eats the average bread of the country: he eats the bread of the locally convenient baker. The people within his circle cannot experience any benefits of enrichment until the practice extends to them.

The extent to which enriched bread and enriched flour currently on sale comply with the federal standards is a matter of interest. Examinations of both bread and flour appearing in interstate commerce are made periodically by the Food and Drug Administration. These indicate that in 1943-1944 about 95 percent are in compliance. Only a small fraction of the noncomplying specimens have shown entire or major omission of enriching ingredients; the large majority exhibit values 10 to 20 percent below standard. No systematic data are available regarding the extent of compliance in intrastate commerce.

Reference has been made briefly to the concern of other food industries over the prominence which enrichment of bread and flour has had in the national program. It is necessary and wise to keep their point of view in mind. Naturally, millers and bakers want to sell as much of their products as they can, and they are not averse to enticing some business away from other competitive industries. The slogan "Eat More Bread," for example, is a popular one, and there is no way of preventing its use. Many nutritionists who have been teaching the importance of variety in foods have advised people to eat less bread, especially in the days when it was of the unenriched variety. No doubt this teaching has been sound where people have tended to subsist too largely on bread. How much effect the teaching can have when the high consumption of bread is due to economic factors is quite another question, but there is no gainsaying that variety in foodstuffs has a primary value for everybody.

The nutritional material put out by the Office of Defense Health and Welfare Services, now the Nutrition Programs Branch of War Food Administration, has borne this principle well in mind. Almost everyone in the country must now be familiar with the "seven basic food groups" which have been preached throughout the land. Rather than engulf people with a muddle of words and phrases about calories, minerals, and vitamins, the office has wisely chosen to emphasize the fact that all foods can be conveniently classified into seven categories and that one or more representatives of each category should appear in the diet each day. The calculation of the vitamin yield to the consumer of a diet represented by a series of menus is no simple matter. It is amazing how frequently the layman will place some unwarranted emphasis upon the occurrence of a particular vitamin in a particular food, and arrive at some bizarre conclusion as to how to select his diet. A vast deal of useless practice of arithmetic on the part of housewives has undoubtedly been avoided by putting the teaching in the relatively simple terms of the "seven basic food groups." This has not only served the main purpose of educating the people in selecting their diets, but has also allayed some of the concern of other food industries.

Several of the larger and more progressive companies in the baking and milling business, as well as in the allied trades, have wisely seen that these industries cannot and should not attempt to monopolize the center of the stage. All the larger food industries, as well as most of the popular utilities which supply fuel, electrical energy, and household appliances to the kitchens of the country, maintain considerable staffs of nutritionists whose sole duty it is to render service to their patrons in connection with the preparation of meals. Under the stimulus of the national nutrition program a great deal of this work has taken on an intensive character. It is not confined to selling the particular commodity which the employer represents, but much of it is devoted to intelligent all-around instruction in the maintenance of a well-ordered table and in the practice of home economics. Some of the major executives of sales organizations in the milling, baking, and allied industries have volunteered for lecture tours in which they have presented not merely the claims of their own commodities, but also the broader aspects of the nutrition program. Several excellent radio programs as well as moving pictures portraying the general features of the whole nutrition program have been paid for by such firms under the approval of the national government authorities. In consequence, it is now felt that food industry as a whole is cordially supporting enrichment.

CHAPTER VIII

WAR AGENCIES IN RELATION TO ENRICHMENT

As the war progressed it became evident that measures which are well justified from the standpoint of public health and the working efficiency of the population should not in war time take the slow course which is tolerable and may even be advisable under peace conditions. The government, having declared itself in favor of the enrichment of bread and white flour by encouraging their production by bakers and millers, appeared in duty bound to put the measure into effect promptly for the sake of immediate benefits from the standpoint of the prosecution of war. The military establishments of the United States had adopted enriched products, the Public Health Service and the National Research Council had strongly endorsed it, and its practicability had been demonstrated by its extensive adoption and practice in both the milling and baking industries during a period of a year and a half.

Accordingly, the first order of the newly created Food Distribution Administration, FDO No. 1, issued December 29, 1942 (see Appendix B-1) included a requirement that "all white bread shall be enriched, shall contain not less than 3 parts nor more than 4 parts of milk solids to 100 parts of flour, and shall contain not more than 2 parts of shortening and not more than 4 parts of sugar or other related fermentable carbohydrate solids." This order became effective January 18, 1943.

The order contained a large number of additional provisions aimed at simplifications and economies in the baking industry to facilitate price control at current levels. Twisting, cross-panning, and dough breaking were prohibited in the production of bread. Slicing of loaves, double wrapping, and elaborate labelling were no longer permitted. Bakers were also instructed to cease consignment selling, i.e., the practice under which unsold stale bread is returned by the retailer to the distributor for credit. The varieties and quantities of certain types of bread produced were also restricted. All these provisions were adopted to avoid the necessity for an increase in the price of bread, which would otherwise have been justified by recent increases in the price ceilings on wheat and flour and by added enrichment costs to those who had not previously enriched their bread.

The purpose of requiring the presence of 3 to 4 parts of milk solids in bread was to maintain or increase its nutritional value to the maximum degree consistent with the available supply of milk powder, and particularly of skim milk powder. A 6 percent milk solids content was sought, but it was found impossible to attain on account of large allocations of milk powder for Lend-Lease export. The restrictions on shortening and sugar were aimed purely at conserving the nation's supplies of these commodities.

Amendment No. 1 to the above order (Appendix B-2) issued January 13, 1943, postponed for 90 days the requirement of 3 parts of milk solids, as it had been found in the meantime that there was an insufficient supply of milk solids even for this level. Amendment No. 2 (Appendix B-3) issued January

25, 1943, modified certain restrictions, e. g., permitted slicing under certain circumstances. Amendment No. 3 (Appendix B-4) of March 6, 1943, likewise contained nothing of special interest from the standpoint of the enrichment program. Amendment No. 4 (Appendix B-5) issued June 17, 1943, removed the requirement of a minimum of 3 parts of milk solids on account of unavailability of supply for all bakers. Amendment No. 5 (Appendix B-6) issued December 11, 1943, sought to extend the requirement of enrichment to all other yeast raised products, of which the most noteworthy items are rolls and buns, and also to all doughnuts, crullers, and fried cakes to the extent that white flour is used. This amendment, effective January 16, 1944, was, however, further amended by Amendment No. 6 (Appendix B-7) issued January 13, 1944, postponing the effective date of the enrichment of bakery products, other than white bread, to May 1, 1944, on account of a shortage in the supply of niacin for enrichment purposes.

When Food Distribution Order No. 1, which concerned, among other things, the enrichment of bread, was issued, effective January 18, 1943, all Food Distribution Orders were designated F.D.O. with a suitable numeral. Later, on April 20, 1944, the War Food Administration issued a regulation changing the designation from F.D.O. to W.F.O. (War Food Order). Since no formal definition for enriched bread had been adopted, enriched bread under these orders was to be made from enriched flour or to have the equivalent ingredients added to it during the preparation of the dough.

WFO 1, Amendment No. 7, issued April 25, 1944, puts enrichment of bread on a more formal basis corresponding to the proposed Federal Security Agency definition of enriched bread. It requires in the finished bread not less than 1.1 nor more than 1.8 milligrams of thiamine, not less than 10 nor more than 15 milligrams of niacin, not less than 0.7 nor more than 1.6 milligrams of riboflavin, and not less than 8 nor more than 12.5 milligrams of iron, per pound. (See Appendix A-16). It also extends this enrichment requirement to all plain varieties of white rolls.

It would appear from the enrichment clause of WFO 1, Amendment 5, that it was the intention of the War Food Administration to extend enrichment also to sweet rolls and to doughnuts when supplies of enriching ingredients become abundant. If this is done, it may well raise a question whether this practice should not be extended into peacetime. In support of the practice is the fact that coffee and doughnuts or sweet rolls often constitute the hurried breakfast or quick lunch of working people, especially when engaged on high pressure schedules. This would appear to call for nutritional improvement of these items. However, there is nothing in support of it in the testimony taken at Federal Security Agency hearings relating to enrichment. Some bakers have evinced interest in extending enrichment to cakes, pastries, and other baking powder leavened goods, as well as to doughnuts and fried cakes. However, the responsible leadership of the baking industry has not taken a stand in favor of it. Enrichment of crackers has been generally opposed as the losses of thiamine during baking of crackers are very great. In cakes and similar baking powder goods the losses tend to be somewhat higher than in yeast leavened baked goods, though not excessively so.

They are not greater than in the home made soda biscuit which is the standard form of bread for much of the South.

Immediately after the issuance of FDO 1 consideration was given to a similar order covering the enrichment of white flour. This was the subject of extended debate in the War Food Administration. Much of the discussion has not been made public. There was more difference of opinion as to whether flour sold to public institutions, hotels, and restaurants should come under this requirement. Particularly as regards state-operated institutions, question was raised as to the propriety of the Federal Government's prescribing matters of food supply. Question was also raised as to the desirability of requiring the enrichment of bakers' flour, and especially all flour to be used for production of cakes, pastries and other goods, in which the loss of thiamine in baking is likely to be higher than in yeast leavened goods. All these matters were thoroughly aired in public hearings held in Washington, July 21, 1943.[22] For the reasons discussed in Chapter VI, the bakers were strongly opposed to the proposal to enrich all bakery flour at the mill. They emphatically preferred to enrich bread in the bakery. Sentiment of the milling and baking industries, as presented at these hearings, was, however, substantially unanimous in favor of extending mandatory enrichment to all white flour used in homes, eating places, and institutions.

In spite of this favorable testimony, however, the War Food Administration did not issue such an order covering any variety of flour and at length on February 11, 1944, announced its intention to postpone such action at least until the supply of niacin for enrichment and other purposes should become more abundant.

The practical effect of omitting mandatory enrichment of flour is a failure to carry the benefits of the enrichment into those areas where home baked bread predominates as in the hot bread belt of the South. It also fails to carry the benefits of enrichment to the inmates of public institutions and to those who eat their meals wholly or largely in hotels and restaurants. These are precisely the segments in which there has been most conspicuous neglect of enrichment on a voluntary basis. Although higher priced southern flours are generally enriched, the cheaper grades are not, except in those states which have mandatory legislation. This has given rise to a strong feeling that mandatory legislation in additional states is highly desirable. Unlike the War Food Administration orders, such legislation would have a permanent effect upon the quality of bread and flour throughout the country. In so far as bread or flour is produced and sold within the boundaries of a single state, state control of the matter is essential for universal success. Federal legislation can directly affect only interstate commerce, which comprises about 90 percent of the volume of flour production but less than 10 percent of the volume of bread production.

It must be clear that some of the measures taken by the War Food Administration with reference to food supplies constitute interventions in the usual peacetime procedures for the control of food quality through the Food, Drug, and Cosmetic Act. They are temporary in nature and will presumably lapse at the end of the war or shortly thereafter. Under the necessities of war, many of the rights which the citizen usually enjoys are temporarily taken away from him and he submits to many inconveniences and hardships which would be regarded as intolerable in peacetime. However, the precise limits of the authority of a war agency are often difficult to determine. Problems are likely to arise as between the war agency and the government authority previously set up for peacetime operation. This sort of question has arisen in connection with food and drug control. Accordingly, the following statement appearing as an authorized interview in the Food Field Reporter of February 21, 1944, will be of interest as an expression of the attitude of the Food and Drug Administration to food problems peculiar to war time:

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[22] United States Department of Agriculture Report on Public Meeting on Enriched Flour Proposal. July 23, 1944.

> "War Food Standards are up to WFA, says Campbell, FDA.
>
> "Washington—Emergency wartime food standards providing for use of ingredients not heretofore generally used and which have not therefore attained consumer acceptance should be promulgated under wartime powers of the War Food Administration rather than under the peacetime statutory authority of the Food and Drug Administration, Commissioner W. G. Campbell said.
>
> "Requests are coming to FDA, sometimes through WFA, from various industry groups for amendment of food identity standards to permit or compel use of certain ingredients either as substitutes or for enrichment purposes, Campbell said. While these ingredients may be wholly meritorious in themselves or when added to other products, such as bread, there has been no general use of them such as contemplated by the standard-making provisions of the food, drug and cosmetic act as a prerequisite to promulgation of official standards, he said.
>
> " 'We in the Food and Drug Administration can easily see the desirability of reinforcing some foods from a nutritional standpoint as an emergency measure, but we feel that the statutory standards should not be used for this purpose unless the statutory requirements are met,' Campbell said. 'Our law clearly limits our standard-making powers to actions which will promote honesty and fair dealing in the interest of consumers.'
>
> " 'It does not empower us to formulate standards based on wartime necessities, however desirable these may be. Furthermore, our procedure necessarily is slow and too cumbersome for emergency use. It never was intended for such use, nor was it intended for temporary inclusion of certain ingredients. If we succumb to the temptation to adapt our standards to every wartime fetish we will end up with food standards in peacetime which are debased and unfair and dishonest to the customer.'
>
> "Mr. Campbell, meanwhile, has notified the soybean industry

and baker representatives that FDA will not recommend at this time final adoption of bread standards tentatively promulgated which provide only for the use of 3% soy flour* in bread. Soybean producers have objected to this and asked for an upping of the percentage of soy flour. FDA opposed this, but has been awaiting an unequivocal recommendation from WFA either agreeing to a definite higher percentage of soy flour or agreeing to promulgate emergency standards to replace the proposed FDA standard for the duration.

"If WFA agrees to promulgate a bread standard permitting a higher percentage of soy flour it is expected that FDA will hold its standard in abeyance until the emergency period ends, then call a public hearing to permit the soybean industry to put in evidence aimed at showing consumer acceptance of soy flour bread. Indications are that WFA is shying away from the idea of using its wartime powers (if it actually has them, which some WFA men doubt) to promulgate food standards."

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* Only 0.5 part of soy flour per 100 parts of wheat flour is permitted by the proposed regulations.

CHAPTER IX

STATE ACTION ON ENRICHMENT

From the beginning of the enrichment program many of its ardent supporters have felt that mandatory legislation will be necessary to make the practice universal. The suggestion has been repeatedly offered that such legislation should be prompted at the federal level in the belief that this would immediately extend enrichment throughout the country. However, the view has prevailed that a widespread practice of enrichment on a voluntary basis was a highly desirable foundation for any attempt at mandatory action. As has already been pointed out, federal legislation would directly affect only those products which are handled in interstate commerce, though it might profoundly influence indirectly the extent of enrichment within each state. It has gradually become evident that both state and federal legislation will be required to make mandatory legislation entirely effective throughout the country. From the very nature of the subject matter of such proposed legislation it has seemed appropriate that it should begin at the state level. By the provisions of the Constitution all general police powers are reserved to the states and any authority of the Federal Government in this matter derives from the general power granted by the states to regulate commerce among them.

As early as the spring of 1941, Dr. E. J. Lease, of Clemson Agricultural College, Clemson, South Carolina, began to consider the possibility of legislation in that state. On May 14, 1941, he wrote a circular letter to the State Nutrition Committee urging its indorsement of such legislation. The Committee met in Columbia, South Carolina, on May 17, 1941, and discussed this proposal at some length. A substantial majority favored the idea but since there was some influential opposition and since the legislature was about to adjourn, the proposal was allowed to lie dormant for some months. In the interval, however, Dr. Lease sought to enlist the support of a number of local organizations to stimulate further consideration of the subject. The South Carolina Home Economics Association, the Women's Council for the Common Good, the State Council of Farm Women, the Federated Women's Clubs, and others participated in presenting the matter on their programs and bringing it to the attention of the public.

Gratified by the interest shown in the proposal, the State Nutrition Committee reconsidered the matter from time to time and early in 1942 decided to undertake the introduction of such a bill in the South Carolina Legislature. Copies of the first draft of such proposed legislation were submitted to several authorities who had had to do with the nation-wide promotion of voluntary enrichment. Various modifications of the proposal, resulting from suggestions so solicited, were gradually fused into the final bill during the course of its discussion in committee.

A feature which was the subject of discussions in the early consideration of the bill was a proposal to tax flour to secure funds to defray the cost of inspection for adequacy of enrichment. This feature, however, was early abandoned.

The first draft of the bill provided that "all white bread sold within the State of South Carolina must be made from the above described enriched flour regardless of whether or not high potency yeast is used." However, when the South Carolina State Nutrition Committee learned about the actual situation in the country as a whole, this provision was modified so as to permit enrichment either in the mill or the bakery. This was done by exempting from the flour enrichment requirement bakery flour sold to bakers who should file a certificate of intention to enrich in the dough stage upon their own premises.

A special provision of the bill which survived the discussions in committee was that which exempted flour produced by custom grinding. In South Carolina, as in all wheat producing areas in the country, a certain amount of wheat is taken to the mill by the farmer where it is ground for him for his own use. Such toll grinding is paid for by the miller's toll or share of the product, usually ranging from an eighth to a sixth of the grain received. In actual practice, the farmer often brings in his wheat and exchanges it for flour produced from some other wheat received a few days or weeks previously. The theory of the transaction, however, is that the farmer is hiring the services of the mill to grind his own wheat. This brings up a nice point in law: namely, has the state authority to require a miller to add something to the flour produced for a farmer under the latter's direction and for his own use? Such authority would amount to prescribing to the farmer what he shall eat, which is quite a different matter from prescribing what he may offer for sale. Partly on the ground of this legal difficulty, but probably even more because of the then considerable opposition on the part of many small millers to interference with their business, and the lack of widespread knowledge and appreciation of the virtues of enrichment at this early date, such an exception of toll wheat from the provisions of mandatory legislation was incorporated in the South Carolina law.

The bill, after extensive amendment above indicated, was introduced in the South Carolina House of Representatives on March 10, passed both houses by March 13, and was signed by the Governor on the following day, to take effect August 1, 1942. This apparently speedy and satisfactory action was merely the conclusion of long discussions with the legislators, preceded by a large amount of careful preparatory work which had been carried on under the guidance of the State Nutrition Committee. Almost every member of the State Legislature had been personally interviewed on the subject by members of his constituency whose interest had been aroused by the organizations enlisted by the State Nutrition Committee, of which Mr. D. W. Watkins, Director of the South Carolina Extension Service at Clemson, was chairman. Mr. Watkins and Dr. Lease have given great credit to Mrs. Nathaniel Gist Gee, the Legislative Chairman for the South Carolina Home Economics Association. Mrs. Gee worked indefatigably in the cause both prior to and during the consideration of the bill in the Legislature, keeping the matter alive but avoiding arousing opposition by importunate demands.

The only opposition presented was in connection with an associated bill requiring the fortification of oleomargarine with vitamin A. This measure was opposed by some distributors of oleomargarine who were already fortifying their product with vitamin A, but who apparently objected to sharing this distinction with other less progressive producers of margarine. Even this limited opposition to a rather distantly related proposal gave same concern at one stage as to how the bill on enrichment of bread and flour would fare. Doubtless any serious hostility to the bread and flour proposal would considerably have delayed action in this pioneer state. The very fact that no other state had yet undertaken legislation for this purpose was enough to cause some disquiet among the senators and representatives. The reason for linking the margarine fortification legislation with that regarding bread and flour was to avoid the implication which might otherwise have arisen that a single industry was under attack. Other southern states which have since considered bread and flour enrichment legislation have followed this lead without cause for regret. It may prove unwise to link the two projects together in some other states where dairy interests are more influential than in the South.

The fortification of margarine with vitamin A is well justified in its own right. Southern consumption of milk and butter is relatively low and the intake of vitamin A is correspondingly often deficient. This is especially true of low-income people who are more prone to substitute margarine for butter because of its lower cost. The legislation requires the addition of vitamin A to the extent of 9,000 international units per pound, a figure which corresponds to the Federal Standard for fortified margarine and approximates that of the lower values of butter. Some butters contain less and some, especially in the spring and summer, contain more. The cost of vitamin A fortification of margarine was estimated at the time to be about $^{3}/_{10}$ of a cent per pound. At present (June 1944) it is considerably less. Undoubtedly the benefit to the general public is amply sufficient to justify this expenditure.

Some further features of the South Carolina bread and flour enrichment law should be noted. It covers white flour, including self-rising flour, and white bread. Specific provision is included for the enrichment of mixed breads composed partly of white flour, by prescribing that their content of the specified nutrient shall equal that of enriched bread. The law provides for the same levels of the required ingredients, thiamine, niacin, riboflavin, and iron, as were prescribed in the then existing federal definition of the enriched products. No mention is made of the optional ingredients included in the federal definition. The Commissioner of Agriculture is charged with the enforcement of the law and is empowered and directed to alter the specifications to conform to future changes in the federal definitions.

Shortly after the successful passage of the enrichment bill in South Carolina, Dr. Lease and Mr. Watkins found opportunity to bring the matter to the attention of the Nutrition Committees of neighboring states with a view to stimulating similar activity elsewhere. The exchanges of correspondence among the leaders of the several southern states soon developed a conviction among them that there existed a number of nutritional problems common to the South which would benefit by joint consideration. Accordingly, Dr. Lease instigated a conference on southern nutritional problems which was assembled at Birmingham on May 23, 1942, at which Mr. Watkins presided. Representatives were present from every southern state. The visitors had opportunity to inspect the hospital wards and to observe a considerable number of cases of deficiency diseases in the clinic of Dr. Tom D. Spies, at Hillman Hospital. There followed a day of discussion of the nutritional problems of the South. Special attention was given to the distinctive features of southern dietaries and a general picture was provided of the progress being made by processes of education to promote better nutrition. Note was made of rice, corn, and wheat as cereal products requiring special attention, and the fortification of oleomargarine and milk with vitamins and iodizing of salt were discussed.

At this conference it was learned that steps were already under way in Louisiana to introduce bread and flour enrichment as well as oleomargarine fortification laws. The leaders in Louisiana were Miss Ellen LeNoir, Chairman of the State Nutrition Committee, and Dr. Howard H. Beard, of the Louisiana State University Medical School and Vice-chairman of the Committee. The organization of the state government is such that matters of food control fall under the authority of the State Board of Health. Accordingly, the bills were introduced early in June through the Committee on Health of the House of Representatives.

Support of the bills was obtained from many state organizations. The State Board of Health joined with the State Nutrition Committee in sponsoring the bills in the beginning. The Louisiana Federation of Women's Clubs, the Louisiana Parent Teachers' Association, the State Dental Association, the Louisiana Farm Bureau Federation, the State Medical Association, the Louisiana Tuberculosis Association, the Charity Hospital, and others added their influence. As was to be expected in the case of such novel legislation, extended discussions took place before the Legislature was persuaded of the broad merit of the idea.

As in South Carolina, the principal opposition centered around the oleomargarine fortification bill, and for essentially like reasons. The bread and flour bill met no industrial opposition. There are very few small flour mills in the state so that there was no occasion for concern in that quarter and the baking industry of Louisiana had, in general, responded favorably to the federal program of enrichment by voluntary action. Undoubtedly, the example of South Carolina had an important influence in the ultimately favorable outcome.

The enrichment bills were passed in Louisiana on July 6, 1942, to take effect October 1st of the same year. The Louisiana legislation differs greatly in wording from that of South Carolina, although the intent of most of its provisions is essentially similar to that of the South Carolina law. Some of the differences in wording of the South Carolina and Louisiana laws arose from differences in state organization or procedure. Others presumably represent merely the preferences of the legal minds which were concerned. Each state which in the future considers legislation on these topics must take into account certain local factors. However, it is most desirable for legislation in the several states to be uniform in character; otherwise the legislation may prove to be very embarrassing with regard to products coming from outside the state. Flour producers in Oklahoma, for example, will wish to be free to ship their products into nearby states without encountering a diversity of requirements in each of them which will introduce peculiarities of composition, packaging, labeling, or the like. Otherwise it becomes necessary for the central distributor to maintain separate stocks of flour conforming to the provisions of each state. A state which ignores the need for uniformity is likely to find that it has unwittingly penalized its citizens by restricting their selection of foodstuffs or by increasing the price of special products which conform to state law.

Action in Alabama was inaugurated in July, 1942, by the State Nutrition Council under the aggressive leadership of Dr. W. D. Salmon of the Alabama Polytechnic Institute at Auburn. The prominence of Dr. Spies' clinic in Birmingham as a national center for the study of deficiency disease was of great aid in stimulating interest in the subject.

In spite of early beginnings, the legislation encountered considerable opposition in Alabama, centering very largely around the proposal to tax flour to defray the cost of enforcement. This provision invited the vigorous opposition of millers' representatives, who felt that it would greatly handicap the sale of enriched products. It was pointed out that the cost of enrichment necessitates a somewhat higher price for enriched, as compared with unenriched, products, and that this discrepancy would only be aggravated by a tax. It was also felt that a tax implied inferiority rather than superiority of the taxed product. The argument in support of the tax feature was essentially a tradition in Alabama that new legislation should carry with it means of defraying the expense which the state would thereby incur. Eventually, however, this feature was eliminated from the bill and it was finally passed in July, 1943, with an effective date of October 1, 1943.

The Alabama law follows fairly closely the provisions of the South Carolina law. No exemption is made for custom-ground flour. The most distinctive feature of the Alabama law is the inclusion of provisions for the enrichment of corn meal and grits. This matter will be discussed in a later chapter dealing with the enrichment of cereal products other than wheat. Proponents of state legislation on bread and flour enrichment should give careful thought to this question before deciding to include the enrichment of products from two different grains in a single law.

An interesting account is available of the history of enrichment legislation in Texas and is given in some detail, since it may be of special service in other states which may desire to foster similar action. It was supplied by Mrs. Jud Collier, of Mumford, Texas, chairman of a legislative committee appointed by the Texas State Nutrition Committee to consider and promote the movement.

This committee had its first meeting on January 20, 1943, when the chairman was authorized to find a sponsor for the bills in the legislature and to secure help in framing the bills so as to adapt them to the Texas governmental organization. It was determined to introduce such legislation through the Senate Health Committee and the Vice-chairman of that committee, Senator Karl Lovelady, agreed to prepare and introduce the bills. A Senate Committee hearing was arranged for February 10th and a House Committee hearing for March 1st. Each Senator and Representative on the Health Committees was furnished with copies of the bills and analyses of them. Members of the Legislative Committee were also given the same information and many contacts were made by telegrams, letters, and personal visits.

At the hearings most of the following sponsoring organizations were represented:

Texas State Medical Association
Texas Dietetic Association
Texas Home Economics Association
Texas Home Demonstration Association
Texas Federation of Women's Clubs
Texas Congress of Parents and Teachers
Texas State Nutrition Committee
Texas Federation of Business and Professional Women's Clubs
Texas State Welfare Association
Texas Bakers' Association
Texas Producers Grain Association
American Association of University Women
Interstate Cotton Oil Refining Company
American Bakers Association
The National Soft Wheat Association
The Millers' National Federation

Discussion developed in the hearings concerning the whole background of the proposals. A particular point of inquiry arose for the first time in Texas, namely, the sources of supply for the vitamins involved. Some evidence of concern developed with regard to the possibility of securing supplies of these vitamins produced within the state. The hearings proceeded satisfactorily, however, and the bills were voted out of the Senate Committee on February 17th and the House Committee on March 1st.

In order to develop sentiment throughout the state in support of the legislation, over 7,000 cards were sent out by the Legislative Committee asking potentially interested persons to write or to speak to their law makers about the matter. The response from the cards was declared to be excellent. The message reached every Representative and Senator and one legislator was reported as stating that every rural and city club in his district had written him. The bills passed both House and Senate in mid-April by large majorities. This was also the case with the bill on oleomargarine fortification which was presented substantially simultaneously and supported by the same group of public service organizations. No newspaper publicity was given to the bills until after they had passed.

The bread and flour enrichment law took effect July 29, 1943. It was modeled upon the South Carolina and Louisiana legislation but appears to be worded in a manner somewhat more consistent with the federal definitions for enriched bread and flour than are the other state laws. Toll ground flour is exempt from its provisions. The law is administered by the State Health Officer.

Laws requiring enrichment of bread and flour have also been enacted in 1944 in Mississippi and Kentucky, bringing the total number of states to six. The Mississippi law was passed without opposition in view of the support of state workers in home economics, agriculture, and health. It takes effect February 1, 1945. Its provisions are similar to those of the other states mentioned above. Companion laws require the enrichment of corn products and the fortification of oleomargarine. In Kentucky the legislation passed without extended debate or serious opposition. It takes effect following the close of the war but contains no other feature requiring special comment.

Informal consideration has been given to similar legislation in Georgia and Virginia and it is expected that it will be proposed to the legislatures in those states at their next sessions. Of the southern states only Tennessee, North Carolina, and Florida have not reported to the National Research Council specific interest and activity.*

Outside of the South only the Illinois legislature has considered such laws, so far as the authors are aware.* These failed of passage but Dr. George E. Wakerlin, of the University of Illinois Medical School, who sponsored the bills in his capacity as Chairman of the Public Health Committee of the City Club of Chicago, has expressed an intention to renew the effort in support of bread and flour enrichment at the next session of the legislature, but to allow oleomargarine fortification to rest for the time being.

A large majority of the states have sessions of their legislatures scheduled for January 1945 and it is anticipated that enrichment legislation will be discussed very widely throughout the country at that time.

In view of the importance of uniformity in the provisions of state legislation, as discussed above, a great deal of consideration is being given to a suitable bill. Committees of the Millers' National Federation, the American Bakers Association and the Associated Retail Bakers of America are jointly considering the form of legislation which, in their opinion, is practicable. A proposed form of a bill was published in "The Facts About the Enrichment of Flour and Bread", an earlier publication of the National Research Council. It has been examined by the Committee on Cereals of the Food and Nutrition Board and appears consistent with the objectives of the national enrichment program.

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* Since going to press, word has been received that all the states in the South are now working toward enrichment legislation and that approximately half the states outside the South are now considering such legislation.

CHAPTER X

THE PUBLIC HEALTH BASIS FOR ENRICHMENT

A concluding statement in the report of the Committee on Diagnosis and Pathology of Nutritional Deficiencies [28] was as follows:

> "All the evidence from numerous surveys over the past ten years to the present among persons of all ages in many localities is without exception in complete agreement that inadequate diets are widespread in the nation. Although an appreciable percentage of the diets failing to meet the Council's recommended dietary allowances were more than 50 percent deficient in amounts of the several essential nutrients, most of the diets were less than 50 percent deficient. Accordingly, there is widespread prevalence of moderately deficient diets."

The poor nutritional quality of several staple foods has contributed importantly to the prevalence of deficient diets. Notable offenders have been white flour and white bread, sugar, highly milled or polished rice, cornmeal, corn grits, and margarine. These staples constitute a large part of the average diet. Sugar, for example, contributes approximately 15 percent of all the calories of the food supplies of the United States; white flour approximately 25 percent. The consumption of rice is on the average somewhat low in the United States, but as much as 100 pounds per capita are used in certain regions every year. In the Orient rice contributes from 80 to 90 percent of the food calories of several populations.

THE LOW THIAMINE CONTENT OF MODERN DIETS

Comparison of American and English diets of recent times with diets of the past (Table I) reveals that modern diets have provided much less thiamine than people formerly were accustomed to receiving. The same undoubtedly is true of niacin. This results because these two vitamins are to a great extent removed from wheat in modern flour milling, whereas less highly milled flour, the product of stone mills, contributed importantly to the thiamine and niacin content of the diets of the past. The change in the supply of thiamine has been radical. The diets of the twentieth century have frequently contained considerably less than 1 milligram of thiamine per day, whereas those of the middle nineteenth century and before, when flour was more coarsely milled and more flour was consumed, provided from 1.8 to as much as 3 milligrams or more of this vitamin.

The failure of many modern diets to supply enough thiamine (and niacin) has not been due entirely to the change in flour from a coarsely milled product, a good source of thiamine, to the white flour of modern milling practice.

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[28] Committee on Diagnosis and Pathology of Nutritional Deficiencies. National Research Council, Bulletin 109, Nov. 1943. p. 46.

TABLE I

ESTIMATES OF THIAMINE CONTENT PER 2500 CALORIES
AMERICAN AND ENGLISH DIETS

Diets	Thiamine mg.
Average American (flour and bread unenriched)[1]—1940	0.8
Poverty American (flour and bread unenriched)[2]—1940	0.6
Middle Class English[3]—1940	0.9
Poverty English[3]—1940	0.6
Philadelphians[4]—1851	2.5
Middle Class, England[3]—1826	2.1
Navy, England[3]—1811	2.9
St. Bartholomew Hospital[3]—1686	1.8
Meat eating classes, England, XV Century[3]	2.3
Peasant classes, England, XV Century,[3]	3.2
Average American (flour and bread enriched)[1]	1.6
Recommended Allowance, Food and Nutrition Board[5]	1.5

[1] Lane, R. L., Johnson, Elizabeth, and Williams, R. R.: Studies of the Average American Diet.I. Thiamine content. Jour. of Nutrition 23:613–624, 1942.

[2] Estimate of the authors.

[3] Calculated from data in Drummond, J. C.: "The Englishman's Food," London, J. Cape, 1940.

[4] Calculated from data in Appx. F, Cummings, R. O.: "The American and His Food," Univ. of Chicago Press, 1940.

[5] For moderate activity.

Contributing also has been a great increase in consumption levels for sugar. Sugar formerly contributed barely 1 or 2 percent of the total calories of the diet. In recent years it has contributed from 15 to 20 percent. The modern diet on the average in several respects is better than the diet of a century ago. More vegetables and fruits, and an increased consumption of milk, have added importantly to the supply of many minerals and vitamins. Milk and most vegetables and fruits, however, are not rich sources of either thiamine or niacin, and very special diet planning is required to provide enough thiamine and niacin, when sugar is consumed in amounts as large as those now used and the flour used is plain white flour. Dependence exclusively on fruits, vegetables, and milk for amounts of thiamine comparable to the diets of the past would require eating more of them than the human stomach could retain. Thus, by Jolliffe's[24] estimation, if a man depended on these otherwise important foods for the amount of thiamine in the American diet of a hundred years ago, when flour was undermilled and more flour and less sugar was consumed, he would have to eat a pound and half of fruit, an equal amount of potato, two pounds of other vegetables and five pints of milk. This combination is of course impossible because of its bulk.

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[24] Jolliffe, N.: A clinical evaluation of the adequacy of vitamin B_1 in the American diet. New Internat. Clinics IV, Series 48, 47-65, 1938.

EFFECTS OF MILLING

Until about 1870 wheat was ground between two stones and the flour thus obtained represented roughly and on the average about 85 percent of the weight of the wheat—an 85 percent extraction. The flour was gray in color and coarse in texture. The modern roller mill first tears the wheat apart between corrugated steel rolls and separates the outer coating of the grains from the inner granules of starchy endosperm. The latter then are ground into flour with smooth rollers. Flour from such milling represents an average yield of 72 percent of the wheat; the balance goes to cattle feed.

Objection to modern milling practices has existed from the time of the development of the modern roller mill. The early critics of the whiter flour had few scientific grounds for their objections, and in consequence they exerted little influence on procedure. Doctors and nutritionists told the people to use whole wheat bread but few followed their advice. The significance of the vitamin contribution made by wheat was first revealed in 1916, when McCollum and associates [25] reported on the presence in the germ of wheat of what they then named water-soluble vitamin B. This report, and other studies on the nutritive value of whole wheat, published soon thereafter by Osborn and Mendel [26] led to serious questioning of milling methods. Studies of the effect of diets low in thiamine on the health and vigor of experimental animals accumulated rapidly, and later similar investigations were conducted using human beings as experimental subjects. Studies of Cowgill [27] provided an early basis for estimation of the minimum human requirement of thiamine, and work by Williams and his collaborators [28] recently confirmed by Foltz, Barborka and Ivy [29] has shown that restriction of the intake of thiamine to a level not below that found by dietary surveys in poorer diets in America caused bodily and mental ill health in persons who previously had been well.

Wheat, but not white flour, is a good source of thiamine and niacin, and a fair source of riboflavin and several other vitamins of what at first was called water-soluble vitamin B but is now known as the vitamin B complex. These vitamins are distributed unequally in the grain and certain of them, notably thiamine and niacin, are concentrated beneath the branny coating of the grain. Some of these vitamins, and again especially thiamine and niacin, are constituents of the coenzymes needed to metabolize effectively such starch as is ingested with ingestion of cereal food. This newer knowledge fully accounted for the harmful effect on diet and health of the milling of wheat and rice by modern processes, whereby the germ and branny layers are milled away and virtually only the endosperm is used for food. It explained the high incidence of beriberi in Oriental populations, and was a major reason for suspecting widespread subclinical avitaminosis in populations like that of the United States, where for seventy years or more white flour has been in general use.

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[25] McCollum, E. V., Simmonds, N. and Pitz, W.: The effects of feeding the proteins of the wheat kernel at different planes of intake. Jour. Biol. Chem. 28:211, 1916.

[26] Osborn, T. B. and Mendel, L. B.: The nutritive value of the proteins of the wheat kernel and its milling products. Jour. Biol. Chem. 37:557, 1919.

[27] Cowgill, G. R.: The vitamin B requirement of man. Yale University Press, New Haven, Conn., 1934, pp. 261.

[28] Williams, R. D., Mason, H. L. and Wilder, R. M.: The minimum daily requirement of thiamine of man. Jour. of Nutr. 25:71-97 (Jan.) 1943.

[29] Foltz, E. E., Barborka, C. J. and Ivy, A. C.: The level of vitamin B complex in the diet at which detectable symptoms of deficiency occur in man. Gastroenterology 2:323-344 (May) 1944.

EFFECTS OF DIETS LOW IN THIAMINE

Diets in which the thiamine content is less than 0.2 milligram per 1,000 calories have been shown to lead quickly to exhaustion of body stores of thiamine and of the coenzyme derived from thiamine. Degeneration of nervous tissue follows, resulting in paralysis from polyneuritis. Diets in which the content of thiamine is more than 0.2 milligram but less than 0.5 milligram per 1,000 calories have been shown to lead in time to depression, anxiety, and fatigue, with resulting loss in mental and physical efficiency. Among the studies made by Williams and his collaborators [30] was one in which diets identical except for the type of flour used were fed to human subjects. When the flour in these diets was either whole wheat or enriched the subjects remained well; when it was plain white flour they developed symptoms and chemical evidences of thiamine deficiency. The study by Foltz and his associates, to which reference was made [29], showed that healthy subjects trained for twelve months to perform a test of strength and endurance became less capable of maintaining work output in this test when the content of thiamine in their diets was lowered to amounts not below those found in many common diets. The diet was composed of "foods selected to represent those commonly found in the American dietary." Both groups of investigators, Williams and his collaborators [30] and Foltz and his associates [29], working independently, came to the conclusion that 0.45 milligram per 1,000 calories might represent a minimum allowance of thiamine for full health and vigor. This for a 2,500 calorie diet would amount to 1.12 milligrams. A study conducted by Harrell [31] showed that children in an orphanage with a diet providing about 0.9 milligram per child daily learned more quickly when their intake of thiamine was increased. The average superiority in eighteen tasks of a group of children given supplementary thiamine over a group of controls on diets otherwise the same averaged 27 percent . In several of the measured activities the superiority amounted to more than 40 percent. The program of tasks selected for objectivity of scoring included accuracy and speed of reading, learning of a code, and solving problems.

Riboflavin deficiency leads to lesions of the various tissues of the body, not the least significant of which are lesions of the eye. The requirement for this vitamin as judged from experiments of Elvehjem[32] with dogs and monkeys is 1.5 times that for thiamine, and diets not containing a rich source of riboflavin, such as milk, are frequently deficient with respect to riboflavin. These observations led to the inclusion of riboflavin in the specifications for enriched flour and bread and when chemical supplies of this vitamin became available it was included.

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[29] Foltz, E. E., Barborka, C. J. and Ivy, A. C.: The level of vitamin B complex in the diet at which detectable symptoms of deficiency occur in man. Gastroenterology 2:323-344 (May) 1944.

[30] Williams, R. D., Mason, H. L. and Wilder, R. M.: Evaluation of nutritive contribution of enriched white flour. Jour. Am. Med. Assoc. 121:943-945 (March 20) 1943.

[31] Harrel, Ruth F.: Effects of added thiamine on learning. Bureau of Publications, Teachers College, Columbia University, New York, 1943, pp. 55.

Niacin deficiency, when severe, is responsible for the principal signs and symptoms of pellagra. Formerly thought to be confined to the southern United States, pellagra now is known to exist throughout the United States. However, more important than pellagra, from the point of view of numbers of persons involved, are the many vague symptoms which can be relieved by increasing the supply of niacin and thiamine. J. B. McLester,[33] reviewing the clinical histories of patients with pellagra at the Hillman Hospital in Birmingham, Alabama, made the significant observation several years ago that an appreciable number of pellagrins had previously come to the hospital with vague symptoms that led to a diagnosis of functional nervousness (neurasthenia). Most physicians experienced in this disease believe that for every patient with frank pellagra at least ten, and probably many more, are more or less disabled by mild forms of this disease that heretofore have not been diagnosed. Upon examination of 198 nurses in New York City, Kruse[34] found 20 percent with subacute changes characteristic of niacin deficiency.

Not only does a borderline supply of any nutrient lead to disability and disease on its own account; it sets the stage for trouble when the person is afflicted by a variety of diseases to which the human flesh is heir. This is particularly true of thiamine. Men live on such a low level of thiamine and the body stores of this vitamin are so rapidly depleted that when any intercurrent malady raises the requirement for thiamine, as many do, a condition of acute deficiency is invited. And so in our hospitals, where formerly there was failure to recognize what was wrong, physicians now are recognizing beriberi or florid thiamine deficiency in conditions masquerading as toxic psychosis, toxic polyneuritis, retrobulbar neuritis, toxemia of pregnancy, and other better known diseases.

It was such considerations that led to recommendations to restore to white flour the vitamins and minerals removed in milling. The quality of the protein in baker's white bread was improved by the growing practice of bakers to incorporate nonfat milk solids in the bread, and it was hoped that restoration of the principal vitamins lost in milling would yield as nutritious, or nearly as nutritious, a bread as the whole wheat bread which many years of education failed to induce the people to take. It was such considerations that prompted Russell Wilder (before the Sixth Pacific Science Congress at San Francisco in 1939) to predict that "the benefit to the public health to be obtained by additions to staple foods of vitamins and minerals, as proposed, would match that heretofore achieved in the field of sanitation." The same considerations inspired Robert Williams (speaking at a meeting of cereal chemists in New York City in 1939) to make this statement:

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[32] Elvehjem, C.: Personal communication to Committee on Dietary Standards, Food and Nutrition Board, June 2, 1944.

[33] McLester, J. B.: Quoted by McLester, J. S.: Borderline states of nutritive failure. Jour. Am. Med. Assoc. 112:2112-2114 (May 28) 1939.

[34] Kruse, H. D.: Personal communication.

> "All these are parts of the large problem which the carbohydrate industries face, that of making their staple products more nearly the equivalent in nutritive value of the whole seed or the cane stalk, as it was once consumed by primitive man. Whether this is to be done by additions of synthetic materials or by retention of the original nutritive components of the crude foodstuffs is a question for industry to decide. To blink at the scientific facts, which will presently become common knowledge, will be suicidal for the commercial enterprises concerned."

OBJECTIONS TO ENRICHMENT OF WHITE FLOUR AND WHITE BREAD

It was not to be expected that the synthetic approach to improvement of white flour would be acceptable to everyone. Opposition has developed, and although this has not been strong it has led to some misunderstanding. Those opposed have based objections on two arguments: (1) that the evidence for deficiency of the average diet with respect to thiamine, niacin, and riboflavin, was inconclusive, and (2) that the better way to meet the problem if there was a problem was by the use of whole wheat or a type of flour that was undermilled.

The arguments of those who held the view that the average diet was sufficient with respect to the vitamins of enriched flour and bread were based on observations that the incidence of vitamin deficiency disease was inconspicuous. Their position was later strengthened by experiments which suggested that requirements for health of thiamine and riboflavin were far below the amounts of these two vitamins in the Recommended Dietary Allowances of the Food and Nutrition Board.

The answer to those who claimed there was no malnutrition has been provided in a fully documented Bulletin of the National Research Council (Bulletin, Committee on Diagnosis and Pathology).[35] It resolves itself into a question of definitions and, to quote from that Bulletin, "admittedly much of the scientific work in support of the importance of optimum nutrition to health loses its strength if the latter term is defined in the narrow sense as 'absense of obvious disease'. The evidence (however) is distinctly significant if one recognizes health as having more positive attributes. In this latter sense health has qualitative characteristics involving efficiency, reserves and the capacity not only to avoid disease but to attain maximum inherited potentialities. This (latter) point of view is the basis of preventative medicine and modern public health practice."

The principal experiments suggesting that requirements for thiamine and riboflavin are less than those accepted by the Food and Nutrition Board have been those of Keys and Holt and their associates. Before considering them it should be stated that the Recommended Allowances of the Food and Nutrition Board contain a factor of safety, to insure adequacy for a fraction of the population which could be expected to have higher than average requirements. This factor of safety or overage in the case of thiamine and riboflavin was estimated at approximately 33 percent. The minimum requirement for thiamine accepted by the Board was 0.45 per 1,000 calories, as developed from experiments of Williams and his colleagues. The figure later was supported by the work of Foltz, Barborka and Ivy.[29]

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[35] Committee on Diagnosis and Pathology of Nutritional Deficiencies: Bulletin of the National Research Council, 109, Nov. 1943. pp. 56.

EXPERIMENTS OF KEYS AND THOSE OF HOLT

The experiments of Keys and his associates [30] were performed with relatively normal young men and involved objective estimations of a wide range of physiological, biochemical, and psychological variables. The latest detailed report available from the Laboratory of Physiological Hygiene suggests that subjects on 0.186 milligram per 1,000 calories for five and a half months had shown no abnormalities. However, when these men were then placed on a diet containing no thiamine (0.006 milligram per 1,000 calories), they began to show signs of deficiency within ten days and broke down in three weeks, four or five days earlier than subjects whose previous intake had been 1.8 milligrams a day.

Despite the suggestion in Keys' study that 0.186 milligram of thiamine per 1,000 calories is less protective than a higher intake, it does appear that the subjects employed by Keys were able to keep in better health than the subjects of Williams, Mason and Wilder on diets containing this much thiamine or more. The urinary excretion of thiamine was very similar in the two groups. Several explanations may apply. First, the subjects in Keys' studies had probably had better lifelong diets than the institutional inmates employed by Williams, though for at least six months prior to the respective experiments the average diets in both cases were relatively poor. Much recent work has shown that the past nutritional experience of the subject affects profoundly the severity of response to depletion of vitamins. Second, the psychological reactions of the conscientious objectors studied by Keys are not comparable to those of the psychiatric patients employed by Williams; neither group can be considered fully representative of average people in the general population. Third, the diets used by Keys differed somewhat from those of Williams, and differences in diets affect the bacteria in the human intestine, as work by Holt has indicated, so that the amount of thiamine derivable from these bacteria may differ. It may be significant also that the proportion of calories derived from fat was not identical in the two experiments; fat provided about 35 percent of calories in Keys' study and from 5 to 10 percent less in Williams' experiments. Fourth, the average caloric intake of Keys' subjects was much greater than that of Williams' subjects, this difference reflecting the difference in the levels of activity of the two groups.

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[29] Foltz, E. E., Barborka, C. J. and Ivy, A. C.: The level of vitamin B complex in the diet at which detectable symptoms of deficiency occur in man. Gastroenterology 2:323-344 (May) 1944.

[30] Keys, A., Henschel, A., Mickelsen, O., Taylor, H. L. and Brozek, J.: Personal communication, June 26, 1944.

In current research at the Laboratory of Physiological Hygiene, conditions are closely similar to those in the experiment discussed above, with the exception that thiamine alone is restricted whereas in the previous study the whole B complex was proportionally reduced. After three months there were already indications that 0.20 milligram of thiamine per 1,000 calories may be less adequate in this experiment than was 0.186 milligram in the previous study. The quantitative relation between thiamine and other members of the B complex is doubtlessly important.

The capacity of intestinal bacteria to manufacture thiamine and other vitamins, a phenomenon called biosynthesis, has long been known to animal experimentalists. It remained for Najjar and Holt to demonstrate that biosynthesis of thiamine and riboflavin could occur in human subjects. Using inmates of an institution for the feeble minded, Najjar and Holt [27] fed a diet composed of vitamin-free foods. They used such foods as washed caseins and dextrimaltose and gave supplemental vitamins. They cut down stepwise with respect to the thiamine allowance, until finally this reached "zero." They later discovered that their foods were not free from thiamine, but contained 0.128 milligram per 1,000 calories. On this intake several subjects developed deficiency symptoms within two months, whereas other subjects showed no evidence of deficiency. The feces of the subjects who did not develop symptoms contained more thiamine than the diet, showing that thiamine was being manufactured in the bowel. A sulfa drug was then given by mouth to sterilize the intestine and promptly thereafter signs of thiamine deficiency appeared in the subjects previously free from signs.

The results obtained by Najjar and Holt (if confirmed) are of great significance. They throw little light, however, on the requirements for thiamine of the American population. In the first place, the feeble-minded subjects were inactive and it has long been known that inactivity spares the need for thiamine. Second, Holt lowered the thiamine gradually, which introduced a variable of probable significance. Third, the use of dextri-maltose in the diet may have favored biosynthesis.

It thus appears to this Committee, and this also is the judgment of the Food and Nutrition Board, that the low figures set by Keys, Holt and their associates as the minimal requirement for thiamine and riboflavin are unacceptable for dietary planning for the population as a whole. In this connection it must be remembered that Williams and his colleagues produced actual paralysis with diets not much lower in content of thiamine than those of Keys and Holt and their associates. Cowgill [27], writing in 1934, compared the "vitamin B" contents of diets in population having beriberi with those of diets where no beriberi was reported. Translated into modern terms, his calculations signify that populations on an intake of less than 0.26 milligram of thiamine per 1,000 calories have beriberi; i.e., gross deficiency disease. Jolliffe[38] recently has reviewed the records of 130 out-patients admitted to the Mental Hygiene Clinic of Bellevue Hospital, New York City. They presented the so-called "neuresthenic syndrome." Of these patients thirty-two had definite signs of polyneuritis (paralysis). Three of the 130 had been eating food that provided only 20 percent of the recommended daily allowance of thiamine and thirteen had received from 25 to 50 percent of the recommended daily allowance of thiamine. These sixteen patients showed polyneuritis. Twenty-two had received from 50 to 75 percent of the recommended daily allowances and of these, twelve had polyneuritis. The remaining ninety-two had received 75 percent or more of the recommended daily allowance, and among them were four cases of polyneuritis. Not all of this paralysis was due to lack of thiamine, but treatment with thiamine corrected the paralysis in more than half the patients so affected.

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[27] Najjar and Holt, E.: Personal communication to Committee on Dietary Standards, Food and Nutrition Board, June 2, 1944.

[27] Cowgill, G. R.: The vitamin B requirement of man. Yale University Press, New Haven, Conn., 1934, pp. 261.

ADVOCATES OF UNDERMILLED FLOUR

The argument of persons who favor flour which is undermilled is based primarily on the thesis that in milling flour other vitamins and minerals as well as thiamine, niacin, riboflavin, and iron are lost. A very few of those who have opposed enrichment with synthetic vitamins have expressed the unwarranted opinion that synthetic vitamins were inferior in some unknown respect to vitamins as they occur in nature. The suggestion even has been made that the synthetic products were harmful or had effects like drugs. The fact is that there can be no possible difference between thiamine prepared synthetically and that which is extracted from a natural source of thiamine, such as wheat or meat. The same is true of riboflavin and of other vitamins that thus far have been synthesized. A vitamin is a chemical compound whether it is made by nature or by man.

The position of persons who hold the view that current standards for enrichment fail to restore other nutrients lost in the milling of white flour is strengthened by a fact, repeatedly admitted from the beginning by those who sponsored the enrichment program, that enriched flour will not support the growth of young rats when this is the only food the rats receive, and that whole wheat flour does a better job in this respect. It must be emphasized that growing young of any species require certain amino acids which are not provided in adequate amounts for growth in diets lacking milk or liver. These growth-promoting amino acids are found to an insufficient extent in the germ of cereal grains and thus in whole wheat flour. A report by Higgins, Williams, Mason and Gatz[39] from the Mayo Clinic has been misinterpreted. In their experiments growing rats were fed a mixed diet designed to represent an adult human diet. It was composed of foods which commonly appear on

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[38] Jolliffe, N.: Personal communication to Committee on Dietary Standards, Food and Nutrition Board, June 2, 1944.

[39] Higgins, G. M., Williams, R. D., Mason, H. L. and Gatz, A. J.: Some results of feeding rats a human diet low in thiamine and riboflavin. Jour. of Nutrition, 26: 347-359 (Oct.) 1943.

American tables, but contained no milk or other rich source of riboflavin. Lacking milk, it also undoubtedly was deficient in some of the protein factors (amino-acids) required for growth. Five diets were fed to five groups of animals. They differed only in the flour used. In Diet E the flour was plain white flour and the rats grew not at all. In Diet F the flour was enriched with thiamine, in Diet G with thiamine and riboflavin, and in Diet H with thiamine, riboflavin, and niacin. In Diet J the flour was whole wheat. The rats on whole wheat flour did the best of all, as was to be anticipated; this is explained by the better protein provided by the germ content of the whole wheat flour. The rats on Diet H (enriched flour) were in every way superior to those on Diet E with the flour unenriched, and this was the conclusion of significance if results of these purely scientific observations are to be drawn into discussion of enrichment.

Owens and McHenry[40] reported on experiments contrasting weight gains of rats receiving different types of flour. In their experiments with growing rats the rations were designed to approximate human dietaries in respect to proportions of carbohydrate, protein, and fat, and bread was supplied in the proportion of six slices per 2,500 calories. The bread was the only source of B vitamins. Under these circumstances Canada Approved white bread was found to be more valuable for inducing increase of body weight than ordinary white bread, but whole wheat bread was markedly superior to the Canada Approved as well as to the ordinary bread. The weight curves of these animals, as reproduced in the publication, seem to show that additions of thiamine and riboflavin to the diets of the rats receiving plain white flour bread promoted quite as great a rate of weight increase as the diets of the rats receiving whole wheat flour bread. It is to be noted that the diet in these experiments contained 18 percent of casein by weight, thus overcoming the inhibiting effect on weight gain of insufficiency of amino acids essential for growth. The inhibiting effect of insufficient thiamine and riboflavin could thus be measured, and it was found that when the bread in the ration was plain white bread weight increase ceased, but that when thiamine and riboflavin were provided the failure was corrected. Later pyridoxine and pantothenic acid were added. These additions, to judge from the published weight curves, appear to have been without appreciable advantage in promoting rate of weight gain. This last conclusion is disputed by the Canadian authors. They maintain that pyridoxine and pantothenic acid had as much effect as had thiamine. Niacin was not given. Much experimentation has shown that niacin is not required in the diet of the rat.

This interpretation of the results reported by Owens and McHenry is supported by a recent study of Westerman and Bayfield.[41] In feeding experiments with young albino rats a B-complex free diet consisted of vitamin-free casein, 20 percent; cornstarch, 60 percent; corn oil, 12 percent; salt mixture and cod liver oil, 3 percent. The casein supplied the amino acids lacking in wheat or flour and the salt mixture the additional minerals needed. The cod liver oil furnished vitamins A and D. The rat does not require vitamins C and K. Therefore, only the B-complex vitamins were factors limiting growth. All animals were fed the B-complex free diet for twelve days and then flour in bread form was substituted for different proportions of the cornstarch. Under these circumstances, when the bread supplied 30 percent of the diet, whole wheat promoted slightly better growth than enriched white flour. When the bread made up 40 percent of the diet, whole wheat and enriched flour promoted the same growth, while at a 50 percent level enriched flour promoted better growth than whole wheat.

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[40] Owens, A. T. and McHenry, E. W.: Observations on commercial bread as a source of B vitamins. Canadian Med. Assoc. Jour. 50:138-141, 1944.

[41] Westerman, Beulah D., and Bayfield, E. G.: Whole Wheat, Morris Type Flour and Enriched Flour as sources of the B-Complex Vitamins. Paper submitted for publication.

However, enriched flour is not primarily designed to be a growth-promoting food. The primary purpose in enriching white flour is, not to produce better bread, but rather to make use of white flour to distribute certain vitamins with which the diet as a whole is inadequately supplied. The improvement of the bread is secondary but the bread also is improved. The baker's practice of adding milk to his loaf overcomes to a very great extent the inferiority in protein of enriched white bread, and the vitamins added are those which are mainly lost in milling flour. The position of those who insist on whole wheat is that of starving men who would refuse the better part of the loaf because they cannot have the whole. They argue that the part is enemy to the whole.

CHAPTER XI

RELATION TO OTHER NUTRITIONAL REFORMS

Every crusader is likely to become so zealous in the advocacy of his cause as to neglect or at least under-rate the importance of all other causes of a more or less kindred nature. Those who are supporting the enrichment of bread and flour are desirous of avoiding such an error. We would not appear to ignore the fact that other nutritional reforms are possible and that many of them are making useful progress concurrently. The great merits of the program of bread and flour enrichment lie in the possible immediacy and universality of its effect. Measures which can be introduced into the industrial production of food supplies create a channel through which benefits flow automatically to the population without waiting for the slow processes of education and economic change to take effect. Once established, these commercial channels tend to maintain themselves since they harness the competitive profit motive to the public weal. Bread and flour are so universally consumed in significant amounts in the United States that the effect of improvement in their nutritional quality will be almost universally felt in so far as popular dietaries require this sort of improvement. On the average they are consumed daily to the extent of the equivalent of 6½ ounces of flour and furnish 25 percent of the caloric intake. The costs of enrichment are also within the means of everyone and this is very important in the case of staples such as bread and flour, which are consumed in increasing proportions the lower the economic status. Recognition of these merits is no denial of the value of other approaches.

As one contemplates possible mass nutritional reform one turns almost inevitably to repair of the B deficiencies and in turn to consideration of the staple grain supply. Most of the widely prevalent deficiency diseases affecting populations en masse have been associated with defective cereals. Scurvy, it is true, has long been known and while it is found scattered widely among general populations and particularly among infants, its most conspicuous occurrences have been on sailing ships, on polar expeditions, in prison camps or in beleaguered fortresses. Relief from the unusual conditions implied by these circumstances has commonly led to prompt relief of the florid scurvy. Lesser degrees of vitamin C deficiency are widespread and a means of securing wider distribution of this vitamin must be sought. Rickets likewise has been long known and has an intimate relation to the food supply and especially to the calcium phosphorus balance. It is primarily a disease of infancy and associated with a diet of cows' milk. The factor of sunshine, however, is so important as to make the control of rickets a matter of sanitation as well as of nutrition. Vitamin A deficiencies are also thought by some authorities to be widespread but no great populations have been prevailingly affected by them, and it is difficult to put one's finger on a single corrective measure which would be almost universally effective. The fortification of oleomargarine is the nearest approach to such a measure and this has been advocated in parallel with bread and flour enrichment.

In addition to these vitamin deficiencies there are protein deficiencies of widespread importance. They are associated very largely with the need for increased supplies of milk and lean meats, especially for low-income people. It is the economic difficulty which one encounters in attempting reform along these lines, though partial escapes are possible through the use of cheaper vegetable proteins of superior quality as these become available and popular. If incomes were always adequate to meet the needs of proper food supply no doubt a large fraction of all nutritional faults would be abolished. That difficulty, however, is as old as human society and no immediate remedy can be foreseen.

Largely by a process of elimination one arrives at a consideration of the staple cereal supply as the one most accessible point for significant mass nutritional reform. It was the widespread occurrence of beriberi in severe form among oriental populations directly as a result of the almost exclusive consumption of white rice that was responsible for bringing into being a large part of our modern knowledge of vitamins in relation to nutrition. It was in the Orient that the existence of nutritional deficiency disease was first firmly established. The extreme simplicity of prevailing oriental dietaries greatly facilitated and accelerated the recognition of the etiology of the disease. It was in the Orient that vitamin B_1 was first isolated. In a sense the identification of the scurvy vitamin was an outgrowth of the oriental work. Holst and Frolich first encountered scurvy in guinea pigs in attempting to produce ship's beriberi in these animals, instead of using birds.

It was also in the orient that the first mass nutritional reforms were attempted. Some of them, notably Takake's revision of the Japan navy ration, preceded the recognition of the existence of such a thing as a vitamin. Others promptly followed the first experimental studies which indicated that the deficiency was of a substance of a specific organic nature. By the substitution of unpolished rice for white rice in the ration of the Philippine Scouts in the year 1911 the occurrence of beriberi in these troops was almost completely eradicated. Most people in America scarcely knew of the Scouts at that time and only made their acquaintance during the course of their heroic stand against the Japanese on Bataan. The Filipinos, of course, knew about them from the time of the initial organization of the corps, and took great pride in their efficiency and military smartness. Yet all attempts to copy the Scouts' example in the matter of rice supply for the benefit of the civil population of the Philippines have failed. Legislation seeking to limit the consumption of white rice by a heavy tax on it from which unpolished rice would be exempt was introduced into the Philippine Legislature in 1911 and has been re-introduced repeatedly in subsequent years, but in vain. The popular preference for white rice has been sufficient to overcome all the evidence. Theoretically, we have known for thirty-odd years how to prevent beriberi but effective measures have not yet been adopted in any oriental country. Thus we see concrete evidence that the major problem in mass nutritional reform is not to acquire sufficient scientific knowledge but to secure its popular acceptance.

While it was long supposed that vitamin B_1 deficiency was largely limited to oriental rice-eating peoples, or others restricted to some such bare ration as hardtack, there has for twenty years been an increasing recognition of the occurrence of this deficiency among people having more liberal dietaries such as those which prevail in the western world. The idea that white flour is more or less in a class with white rice as a deficient staple foodstuff has been voiced with increasing frequency ever since World War I.

One of the earliest attempts at reform in this regard was undertaken in Switzerland. An account of it was published by H. Muller in 1939[42] and a summary was presented that same year at a European conference on rural life of the League of Nations.[43] The gist of the plan was to encourage the long extraction of wheat in flour production by putting a tax on the mill by-products. This tax was so adjusted that long extraction flour, as well as the bread produced from it under the name "pain integral," sold about 25 percent cheaper than the corresponding white products. The plan was put into effect with the aid of a government-sponsored educational campaign. During the first month of 1937, when the new products were introduced, about 75 percent success was achieved with regard to the entire bread and flour consumption. This high level, however, endured only a few weeks and the decline continued steadily throughout the year. By the beginning of 1938 consumption had fallen to 16 percent and at the end of the year to 11 percent. At last accounts the consumption of the long extraction bread was no greater than that of brown bread prior to the inauguration of the experiment.

Many local attempts to expand the sale of brown breads, and particularly of whole wheat bread, have been made in America. Many of them have been local and some such enterprises still continue successfully, though on a relatively small scale.. By making show places of their mills and by playing up the tastiness of freshly ground flour the enthusiasts are able to maintain a profitable market for a limited distribution of whole wheat bread to a select clientele. Some have succeeded in extending such businesses over somewhat wider ranges, at a premium price. A notable example is Pepperidge Farm Bread.

A noteworthy example of an attempt at marketing of whole wheat bread at standard prices was that of the Continental Baking Company undertaken in 1941. The firm is reputed to be the largest baking concern in the United States and operates scores of bakeries from coast to coast. The new product was called "staff bread," made from a flour produced by special process which included nearly the whole of the grain in the flour, eliminating only the outermost coats known colloquially as "bees' wing." An extensive advertising and sales campaign of this product was inaugurated almost simultaneously with the adoption of the enrichment program by the leading bakers and millers of the country. It is said that more than $1,500,000 was expended in developing and promoting it. Many of the enthusiastic supporters of the enrichment program felt at the time that staff bread was riding on the coattails of the national nutrition program and was attracting attention away from the enrichment idea which had found favor with competing firms. This was undoubtedly true for the time being but after the lapse of a few months the early success of staff bread promotion began to languish and within a year the nation-wide attempt had to be abandoned altogether for lack of public demand. In the end this ambitious and expensive attempt merely served to prove anew that the American public is not ready for whole wheat bread.

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[42] Le pain "Integral", Schweizerische Medzinische Wochenschrift, v. 20, pt. 1 (No. 14), Apr. 8, 1939, pp. 321-324.

[43] League of Nations European Conference on Rural Life, General Technical Documentation; Rural Dietaries in Europe, Annex: Report on Bread, p. 47-48, August, 1939.

There are still many ardent advocates of whole wheat bread among the nutritionists of the United States. Lepkovsky has very well summarized their viewpoint.[44] In so far as the advocacy of whole wheat is concerned, many of the leading proponents of the present enrichment program wish it well, though they see no prospect of its success within our lifetimes. The question is not that which Lepkovsky assumes it to be, namely, whether whole wheat is preferable to enriched products. Concerning that matter no person familiar with the facts would wish to take a stand for the superiority of enriched products from the standpoint of nutrients supplied. Some of the superiorities which Lepkovsky claims for whole wheat are debatable, but on the whole its nutritional faults are neither serious nor irreparable. Its merits over ordinary white products are incomparable. The real question, as the Committee sees it, is not wholly one of nutritional science but is also one of practical feasibility. Is it wiser to expend a vast effort for a 5 or 10 percent success affecting only the most teachable (and in general the least needy) fraction of society or to achieve promptly a universal betterment though perhaps not the most ideal solution?

Lepkovsky recounts the past experience in England and Denmark with dark war breads in World War I but overlooks the significance of the fact that these war measures were promptly abandoned in peacetime. He passes over the 1937-1939 experiment in Switzerland above cited, as only a verbal report, having overlooked the principal literature on it. He also overlooks the very recent and significant failure of "staff" bread in the United States. He writes with approval of the present Canadian program but apparently was unaware that, though the two have been in progress simultaneously, the Canadian effort has only been one-tenth as successful in terms of proportions of flour and bread affected as that in the United States, which he condemns. He appears to accept the allegation that millers prefer to produce white flour in spite of public willingness to accept whole wheat. Mill by-products always sell at very much lower prices than flour does, and it seems obvious that some millers would turn to whole wheat with alacrity if they could sell all their product at flour prices. The baker likewise is in business for profit and would as lief sell whole wheat bread as white if the public would buy it.

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[44] S. Lepkovsky: The Bread Problem in War and in Peace. Physiological Review, 24: 239-276, 1944.

Lepkovsky also misunderstands the limitations of government authority. The war food controls did not come into existence till two years after the first steps toward enrichment were inaugurated. The program was on a voluntary basis as regards bread until January 1943, and still remains on a voluntary basis as regards flour as far as the Federal Government is concerned. Enrichment of flour is merely *permitted* in interstate commerce. The idea that the government accepts responsibility "to improve the nutritional level of the population whether they like it or not" did not apply at all when the program was inaugurated and will not apply at all when the war is over. Its application even in wartime is greatly limited by the fact that popular government cannot take unpopular measures except when a dire necessity is established in the public mind. Let anyone attempt to persuade Washington or any state capitol to make whole wheat mandatory even under present circumstances and he will soon discover how impossible that is.

Some misstatements of fact in Lepkovsky's paper should be noted. The enrichment standard on which he bases his calculations had been superseded by the new standard six months before his paper was published, and the new standard had been published July 3, 1943. Riboflavin was never an optional ingredient as he states. His figure for thiamine content of whole wheat flour is far too high, if soft wheats are included. These wheats are exclusively used for hot breads in the South, where deficiency disease tends to be most prevalent. His views are illustrated by two statements: "Its (whole wheat flour) instability is a commercial problem which has proved no obstacle in the past. . . ." "The unpalatability of whole wheat bread and the alleged refusal of people to eat it are myths and have no foundation in fact." He appears to think that most brown bread is whole wheat bread.

There is, of course, no law anywhere in the United States which prohibits or discourages whole wheat flour or bread. Both have a perfectly free field, as they should. They are everywhere permitted just as enriched flour is permitted.

In countries where white bread has not been generally introduced, as in Russia, dark breads have continued over long periods of time to be acceptable to the masses, though by no means to the exclusion of white. Usually where dark breads are used, considerable portions of the bread supply are of rye rather than wheat. Even in western Europe, where white bread has long been available, certain dark breads remain popular. Some of them are of the nature of specialty breads, yet as a whole they are consumed in lands where they are traditional—for example, in Scandinavia, in rather larger proportions than are brown breads in the United States. Accordingly, it cannot be said that dark breads are by any means universally distasteful to the masses of humanity. Yet in all countries where white breads have become widely established, as in Switzerland, it has proven extremely difficult to move in the opposite direction. The prevailing bread of the countries along the western coast of the European continent is white. In Belgium, France, Italy, and Spain, as well as in England, large amounts of white bread are consumed in peacetime and the trend up to the beginning of the present war showed no drift toward darker breads.

Reference has already been made at some length in Chapter I to the wartime movement in England for the modification of the bread supply. In July 1940, a decision was announced that white flour would thereafter be fortified with vitamin B_1. The issue, however, presently became extremely controversial and little was accomplished for several months. During this period preference on the part of the government for nutritional improvement of the flour by retention from the grain became well established and an attempt was accordingly inaugurated during 1941 to introduce long extraction flour on a voluntary basis. An extensive campaign of government propaganda was undertaken but reports to Parliament a year later indicated that it had achieved little popular acceptance. More stringent measures were taken by the government in April 1943, when the use of long extraction flour was made mandatory and the sale of short patent flours was prohibited. In addition to prescribing long extraction, the Food Ministry requires the addition of calcium carbonate in the proportion of 7 ounces per 280 pound sack (280 milligrams of calcium per pound).

This regulation has been accepted in good spirit by the British people, who have undergone other and greater hardships with admirable courage. The entire British dietary under war conditions is monotonous and relatively unattractive. It nevertheless provides very well for the nutritional needs of the people and there are many evidences that public health has been gaining rather than waning under it because of the more equitable distribution of the available food supply through rationing. Whether long extraction bread will be popular in peacetime is quite another matter. Several of the leading advocates of the present British flour have already been convinced that a return to white bread will be demanded.

Whatever the issue on that score, the British course of action has well justified itself under the conditions prevailing throughout the British Isles. Under the constant threat of deprivation of essential food supplies by submarine blockade, it was necessary to import the greatest possible amount of food with the available shipping. Importation of wheat in the form of grain rather than in the form of flour was a virtual necessity to facilitate long storage and it was also imperative that a maximum amount of flour should be derived from the wheat which could be delivered to British ports. Extensive flour milling facilities were available and there was great demand not only for the flour but also for all mill by-products which could be derived from imported wheat. An essential feature of the British bread policy has been to encourage the substitution of home grown potatoes for bread from imported wheat as far as possible. As a means to discourage the consumption of bread and force the shift to the use of potatoes, the sale of fresh bread has been prohibited. Bakery bread must be twenty-four hours old before being placed on sale. There seems little doubt that all of these measures, extreme though they are, have actually been required under the circumstances.

CANADA APPROVED FLOUR AND BREAD

The following statements come from official sources in Ottawa:

> "The Canadian situation has, of course, been very different. Without any threat of curtailment of her food supply by interruption of

shipping and with large excess supplies of wheat on her hands, Canada was free to follow whatever course she chose. There appears to have been general agreement among the Canadian authorities from the outset of the war that some nutritional improvement of the bread and flour supply was in order. Agitation with this object in view began as early in Canada as in the United States. However, it took quite a different trend for at least two reasons:

"(1) Canadian wheat has an exceptionally high thiamine content and is well adapted to an attempt at producing white or nearly white flour with better retention of the original thiamine than is obtained in an ordinary white flour.

"(2) Canadian authorities appear to have been satisfied with a modest thiamine level in the flour, such as would be sufficient for the utilization of the carbohydrate calories, and such as would permit the white flour to 'pull its own weight' in the nutritional picture but without any other attempt to make flour or bread solve nutritional problems of the nation.

"Experimentation by government authorities with the cooperation of certain Canadian millers showed that these objectives could easily be reached both by drier milling and by other methods. In January, 1942, the standard for 'Vitamin B White Flour (Canada Approved)' was set at a minimum of 1.2 mgs. thiamine per pound at 13.5% moisture. This action was taken after a meeting of millers, bakers, nutritionists and Dominion Government officials and it went into effect April 1st, 1942. Although some suggestion had been made that different kinds of flour should be clearly defined in Canada, a situation which already existed in the United States, this was the only definition of a white flour evolved. The regulation included the provision that the use of synthetic vitamins in flour and bread would be deemed adulteration, which was in keeping with the whole history and policy of the Canadian Food and Drugs Act.

"Pessimistic views as to public acceptance of the product have frequently been voiced. Examples of difficulties with this white flour in the early days have been traced to variations in quality permitted by the looseness of the definition. The definition was changed to read 1.2 mgs. thiamine on a moisture-free basis, and to include limitations as to the ash content, in September, 1943, as a result of meetings between industry and government representatives in January, July and August, 1943. At these meetings it was apparent that some millers and some bakers were able to produce consistent and satisfactory products under the definitions, while others still doubted their suitability. Lack of support by millers and bakers has undoubtedly been due to the absence of a suitable publicity angle for Canada Approved White flour and bread. It is not spectacular. (See Larmour in the Canadian Baker, August, 1944.) This new definition for white flour and white bread of a nutri-

> tionally desirable type has had almost no publicity except for government bulletins and no claim has been made that it would do more than 'make it easier for the Canadian public to choose foods which will give adequate nutrition.' There is, therefore, no real parallel with the enrichment programme in the United States.
>
> "No average figure can be stated as to the probable consumption of this new type of flour in Canada although some facts are known. All the Armed Services in Canada use nothing else but Canada Approved flours. The great majority of industrial cafeterias use it. A recent (1944) survey of some large bread companies showed an average of about 40% of their production but this may be deceptive since some companies do not use it and others make all their bread with Canada Approved White Flour, even though it may be given several different labels."

The view of the Canadian Millers' Association is less favorable[45] than the official view above cited. The feasibility is questioned of achieving in commercial practice the thiamine level required and it is said that only 7 percent of the total consumption of flour in Canada is of the improved variety. The exceptionally high average thiamine content of Canadian wheat is disputed by some United States authorities.

It is of interest to report that the government of Newfoundland has recently decided to introduce the mandatory enrichment, according to United States formula, of all bread and flour sold in the colony, effective July 1, 1944. Newfoundland has long been a hotbed of B deficiency disease and it will be a matter of great interest to note the effect of the introduction of enrichment upon public health. A survey of the present situation with regard to the incidence of nutritional disease has been made for comparison with the results of similar surveys to be made in subsequent years.

The greatest single merit of the bread and flour enrichment program is that it promises to accomplish something definite and tangible promptly and inexpensively. Its most ardent advocate will not promise or expect complete alleviation of nutritional disease by its adoption. It is, however, notorious that the incidence of nutritional diseases is highest in groups where the income is lowest. Indeed, there is an excellent inverse correlation between nutritional welfare and income throughout a wide range, as shown by the studies of Stiebeling and Phipard in the United States and of J. B. Orr in England. It is, therefore, of the utmost importance from the standpoint of securing prompt action that the costs of nutritional betterments be given primary consideration. No other element of the national nutrition program can compare with the promise of bread and flour enrichment in this regard.

Actually we know perfectly well that we are not going to succeed in getting everyone to drink an extra glass of milk per day. First, we cannot possibly get the message to everyone in a sufficiently persuasive way; second, if we did, there is not enough milk in most states to go around, and third, there is the matter of costs per person per year, which, comparatively for various other proposals in the national nutrition program, are as follows: the vitamins and iron and their addition to bread and flour, \$0.18; 4 eggs per week @ 30¢ a dozen, \$5.20; 1 orange per day @ 36¢ per dozen, \$10.95; 1 glass of milk per day, @ 14¢ per quart, \$12.77. The above cited enrichment cost includes the addition of thiamine, riboflavin, niacin, and iron in accordance with the revised standard which went into effect October 1, 1943.

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[45] A review of the Vitamin B White Flour (Canada Approved) Program and the History of Flour Enrichment in the United States. Prepared by A. W. Alcock for the Canadian Millers' Association April, 1944.

These other nutritional reforms will actually cost the consumer who does get them from 50 to 100 times as much as the benefits of enrichment of bread and flour. Perhaps some can shave these money outlays appreciably by keeping a cow or pigs or chickens, but if they do raise the products they will have to expend time, money, and labor in doing so. The town dwellers cannot do so in any case, and the poor and especially the shiftless will not have the capital to do so. No, we must face the inescapable fact that enrichment of white flour and bread will do vastly more for a dollar in the interest of the poor than any other feasible food reform.

An important nutritional reform which has had considerable success both in Europe and the United States is that of providing a special meal for school children. A famous and early form of this undertaking was inaugurated in Oslo, Norway, some twenty years ago and has become known as the "Oslo breakfast." It consisted of the following, served in the morning at school to each child before the beginning of classes:

1. a. Half an orange at the beginning of the meal to stimulate the appetite
   b. One-third of a liter of milk.
2. One hard wholewheat biscuit or a piece of hard whole-rye bread (knekkebrod) with vitaminized margarine and rich cream whey-cheese.
3. As much as the child likes of ordinary whole-wheat bread with whey-cheese or cod-liver paste.
4. A raw carrot or an apple.

It will be noted that the articles of food chosen for inclusion are calculated to supply unusual amounts of the several vitamins and other nutrients in well-balanced proportions to make up for the deficiencies of the diet which the child may receive at home.

In the United States the school meal program has prevailingly taken the form of a midday lunch. This program, administered by the Civilian Food Requirements Branch of the War Food Administration, provides to participating schools a cash reimbursement for part of the food costs, or donations of food purchased through market price support programs. For example, a school serving a complete lunch with a glass of milk may receive up to nine cents a meal from federal funds. For a less complete meal, the cash allowance may fall as low as four cents or two cents for milk alone. Cash allowances are made for only one meal per day per child. Costs of the meal in excess of the federal allowance are cared for in some states by state funds and in other areas by local boards of education. In many instances children who are able to pay are charged for the meal, but federal assistance is conditional upon the provision of a free meal to children who are unable to pay. The program is operating in every state in the Union and has affected five million children in thirty thousand schools. It represents the most successful country-wide attempt to supplement meager diets among school children by at least one well-rounded meal a day. Unfortunately, the poorest school districts are often unable or unwilling to provide by local funds for the costs above federal aid.

CHAPTER XII

SUPPLIES AND COSTS OF ENRICHING INGREDIENTS

Of the vitamins in use for enrichment purposes, thiamine was the first to be produced in substantial volume. Commercial production began in 1936 in small volume and the product at that time sold at $10.00 per gram as compared with $400.00 per gram for the pure vitamin isolated from natural sources. The demand for thiamine for experimental purposes was relatively large as soon as the synthetic product became available. There followed shortly a large number of scientific papers dealing with its clinical uses and the demand for therapeutic purposes rose steadily as increasing quantities came on the market. During the latter part of 1940 the price had been progressively reduced to about $1.00 per gram.

The demand for niacin and riboflavin as well as for dry iron preparations for food purposes was relatively minor until enrichment of bread and flour was proposed at the flour hearings in November 1940. Production of adequate supplies of niacin presented no major scientific problems, but a large amount of development work on a factory scale was required before an economical process of production was evolved. Iron reduced by hydrogen for enrichment purposes was already available and it was only necessary to expand the output.

The supply of niacin has, however, continued to be somewhat scanty, partly because of the rapidly rising demand for enrichment especially in view of the higher levels which came into effect October 1, 1943, partly because of increased demand for export to our allies, and partly because of shortages of raw materials and reagents. It is made chiefly by oxidation of quinoline derived from coal tar. The facilities for production of quinoline have been barely sufficient. Niacin has been allocated for enrichment purposes without interruption but the margin of supply has been inadequate for safety. However, measures have been recommended which should eliminate any danger of shortage by mid-autumn. Niacin was formerly produced from nicotine, whence its name nicotinic acid. With the approval of the Food and Nutrition Board the use of the name "niacin" was accepted to avoid the false popular impression that something akin to nicotine was being added to foodstuffs.

Riboflavin presented a difficult synthetic problem. The resolution of the scientific and technical problems required a long period of time and it was not until the late spring of 1943, fully two years after the inauguration of the enrichment program, that adequate supplies of riboflavin began to be available. This fact was reflected in the repeated postponements of the riboflavin requirement under the federal definition for enriched flour. This requirement was finally put into effect October 1, 1943. When it took effect it added abruptly and materially to the costs of enrichment and there was concern for some time that these increased costs would lead to retrenchments by millers in the practice of enrichment, but this was promptly met by price reductions for all ingredients. The slight color contributed by riboflavin to white flours was also a matter for unfavorable comment. However, concern about the matter has diminished with experience.

The progress of the enrichment program has been greatly facilitated by an increasingly far-sighted attitude on the part of vitamin producers with regard to reduction of prices as volume of sales has expanded. Because of the historical facts about their introduction into commerce, the vitamins were at first regarded by many as belonging to the pharmaceutical trade. However, as demand for enrichment purposes grew this outlet has come to be recognized as the controlling factor in the situation. Wholesale prices of each of the three principal vitamins at successive intervals are indicated in Table 8. Figure I shows the course of the sum of the costs of enriching ingredients for enriching 100 pounds of flour from the beginning of 1941 to date.* These prices are those of the bare nutrient ingredients and do not cover the diluent and processing of premixes nor the costs of mixing the ingredients uniformly into flour or bread. No allowance is made for the small amounts of nutrients naturally present in flour nor for any factor of safety such as good commercial practice requires.

The Office of Price Administration allows millers to sell enriched flour at a price sufficiently above that fixed for ordinary flour to cover prevailing enrichment costs. The officially recognized overall costs of enrichment were 12 cents per 100 pounds of flour, according to the latest adjustment of price ceilings. The nutrient costs per pound loaf of bread are now between 0.05 and 0.06 cent; no price differential has been allowed for enriched bread over ordinary white bread.

TABLE 8

PRICE OF ENRICHING INGREDIENTS AT SUCCESSIVE DATES

Date	Thiamine per gram	Riboflavin per gram	Niacin per pound	Iron per pound
Jan. 1941	$0.80		$8.00	$0.70
May	0.65		8.00	0.70
Jan. 1942	0.53		7.50	0.75
Apr.	0.48		6.50	0.75
July	0.41		5.50	0.75
Oct.	0.37		5.00	0.75
May 1943	0.32		5.00	0.75
July	0.29		5.00	0.75
Oct.	0.29	$0.49	4.09	0.75
Nov.	0.265	0.43	4.09	0.75
Jan. 1944	0.25	0.38	3.63	0.75
Feb.	0.20	0.28	3.18	0.75
Aug.	0.18	0.23	3.18	0.75
Oct.*	0.16	0.20	3.18	0.75

*These figures received after going to press.

The ownership of the patents controlling the production of thiamine by Research Corporation, New York City, has been an important factor in securing a progressive reduction in enrichment costs. Research Corporation is in effect a non-profit organization, since its management of patents is for the production of revenues with which to support scientific research. Its policy with respect to thiamine patents has been guided by a consideration of the public benefits to be derived by the enrichment program and the obvious dependence of the extent of enrichment upon the costs of the necessary ingredients. The thiamine price policy has in turn set the pattern for the pricing of other vitamins. Those vitamins which have come into prominence for purposes of enrichment of staple foods have become cheaply available on the market both for enrichment and pharmaceutical purposes.

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* Enrichment of bread with high vitamin yeast cost somewhat less than with synthetics during the first half of this period.

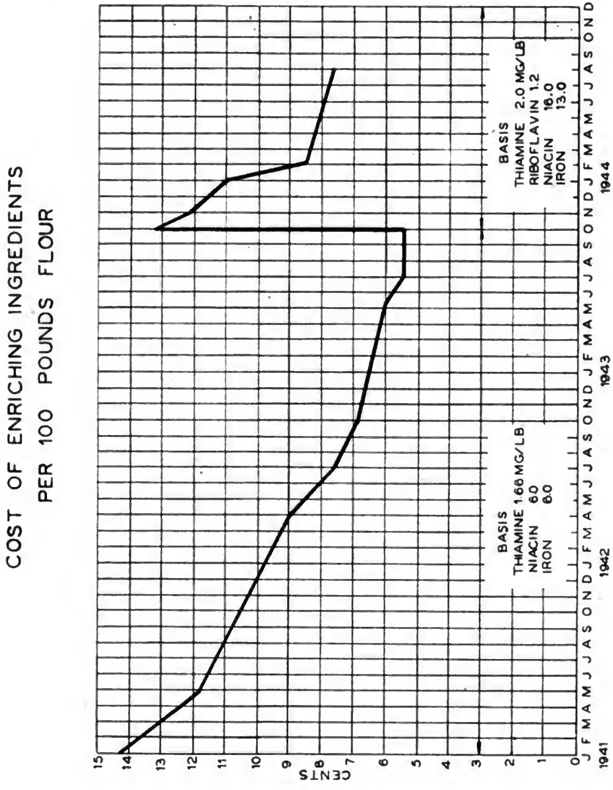
The pharmaceutical use of the enrichment vitamins still remains an important factor in the market. Under war conditions it is not permissible to publish details of allocations of vitamins for various purposes. A few significant data, however, have been released by the War Food Administration in a press release of March 29, 1944. About 74 percent of the thiamine allocated in 1944 is expected to go to civilians, about 9 percent to our armed forces, and about 17 percent to our allies and other friendly nations. Of the allocation for United States civilians, 56 percent of the thiamine will be used to enrich food and about 44 percent will go into pharmaceutical preparations. In the case of riboflavin, about 84 percent of the total allocation goes to United States civilians, of which slightly less than half is designated for food enrichment purposes and about 40 percent for pharmaceutical preparations. Niacin is produced in two forms: the free acid and the amide. The bulk of the former is used for enrichment and nearly all of the latter for pharmaceutical preparations. A little more than 60 percent of the 1944 production of both acid and amide will be allocated to United States civilian uses: 95 percent of the amide is for pharmaceutical use and 98 percent of the acid is for food enrichment. The latter is many times larger in quantity.

About twenty-five firms are engaged in supplying enrichment tablets, wafers, or premixes for the use of millers or bakers. As many of these firms have representatives at many distribution centers, supplies and technical information about enrichment are available in every section of the country.

Disinterested information about enrichment from the standpoint of the baker and miller can also be obtained from the American Institute of Baking, 1135 Fullerton Avenue, Chicago, Illinois, or from the Wheat Flour Institute, 309 West Jackson Boulevard, Chicago, Illinois.

FIGURE I

To these costs must be added a safety factor as well as feed-in and control costs to obtain total costs of enrichment. See page 85.



CHAPTER XIII

FORTIFICATION OF RELATED PRODUCTS

GENERAL POLICY

From the inception of the enrichment program concern has been expressed in the Food and Nutrition Board as to the ultimate extent to which foods should be artificially fortified. One of the principal criticisms which has been leveled at the enrichment program is that the publicity incident to its introduction is likely to give the public an exaggerated idea of the importance of synthetics in food stuffs and to constitute an invitation to producers of other foods to follow the example of the milling and baking industries. Accordingly, the subject has been debated at great length and repeatedly in the meetings of the Food and Nutrition Board and its committees.

In August 1941, a questionnaire entitled "Which Vitamins Should Be Added to Which Foods and How Much?"[46] was circulated to all members of the Board. A majority of the members of the Board responded to the extended series of questions and the compilation of their replies was brought up for discussion at its next meeting. The almost unanimous thinking of its members was about as follows:

> ". . . that deficiencies arise from two causes (1) losses of nutrients by refining processes, (2) disadvantageous choices of foods. When either of these evils appears to be otherwise irremediable, except by slow processes of education or by unpopular legislation, artificial enrichment may supply a useful remedy.
>
> "The great majority of the Committee deem it important that the aggregate effect of any artificial enrichment of general purpose foods shall have the effect of a closer approach to natural dietaries of good quality rather than a greater departure from such dietaries. Enrichment should accordingly be limited to a few staple general purpose foods and the resulting degree of enrichment of the diet should not surpass the levels of good natural diets.
>
> "Artificial enrichment of foods for general use is sanctioned only for the purpose of rectifying dietary deficiencies which adversely affect substantial segments of the population and which cannot, because of economic restrictions, popular prejudices or other equally valid reasons, be corrected promptly by better choices of natural foods. The chosen vehicles of enrichment shall be those which are consumed in relatively large amounts by all or nearly all people within the affected segments of population. The proponent of an artificial enrichment shall bear the burden of proof of need for such enrichment, of the efficacy of the enrichment proposed and of the absence of secondary adverse influences of such enrichment.

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[46] Food and Nutrition Board Bulletin I, pp. 176-177, September, 1941. Mimeographed.

> "When an existing widespread deficiency of a particular nutrient can be traced in major part to the refining of a staple food, that food shall be the preferred vehicle of that enrichment of the dietary. If such a refined food is artificially enriched, it shall be enriched to levels of each added nutrient within the range of the natural occurrence of each such nutrient in the food in its unrefined state.
>
> "When the existing deficiency in the dietary cannot be traced largely to a refining practice affecting a particular food, any staple food may be chosen as the vehicle of enrichment, provided the food belongs to a type which includes important carriers of the nutrient in question. In such case, enrichment shall approximate the natural levels of the most significant staple carriers belonging to that type."

It is obvious that the need for the fortification of any foodstuff will depend not only on its current nutritive value and the extent to which it is consumed by the public, but also upon the nutrients supplied by all other items of the national dietary. Ideally, a proposal to fortify artificially any particular food would thus require a re-survey of the entire dietary, a labor which is far too great to be repeated each time such a proposal is made regarding a minor food. Yet if there is to be fortification of foodstuffs at all it is necessary that some qualified authority should constantly concern itself with the total effect of all additions which are being currently made. The Food and Drug Administration expressed concern about this aspect of the matter and appealed to the Board for a statement of guiding principles. In response to this request, the following resolution was adopted by the Board on October 1, 1941:[47]

> "Whereas there exist deficiencies of vitamins and minerals in the diets of significant segments of the population of the United States which cannot promptly be corrected by public education in the proper choice of foods, be it resolved, in order to correct and prevent such deficiencies:
>
> "(1) That the Committee endorses the addition of specific nutrients to staple foods (as indicated under 6 below) which are effective vehicles for correcting the above deficiencies in the diets of the general population or of significant age, geographic, economic or racial segments thereof;
>
> "(2) That the Committee opposes the inclusion of additions of specific nutrients under definitions and standards which may be promulgated under the Food, Drug and Cosmetic Act except in the case of foods which constitute such effective vehicles of distribution;
>
> "(3) That the Committee favors unequivocally the fulfillment of the nutritional needs of the people by the use of natural foods as far as practicable and to that end encourages education in the proper choice of foods and the betterment of processes of food manufacture and preparation so as to retain more successfully the essential nutrients native thereto;

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[47] Food and Nutrition Board Bulletin, Vol. I, pp. 192-193, October, 1941. Mimeographed.

> "(4) That to avoid undue artificiality of food supply the Committee favors whenever practicable, the choice as vehicles for the corrective distribution of vitamins and minerals those foods which have suffered losses in refining processes and recommends that the vitamins and minerals added to such foods should preferably be the kinds and quantities native thereto in the unrefined state;
>
> "(5) That the addition of other than natural levels of vitamins and minerals to foods which are suitable as vehicles of distribution may be sanctioned when more natural routes are practically unavailable as measures to correct known nutritional deficiencies;
>
> "(6) That at present the Committee favors appropriate enrichment of flour and bread (and perhaps corn meal), the fortification of milk with vitamin D, the suitable addition of vitamin A to table fats and of iodine to salt for dietary use. There is no information available to the Committee at the present time which indicates that it will be desirable to recommend the addition of vitamins and minerals to foods other than those named.
>
> "(7) That specifically the Committee opposes the addition of synthetic vitamins to carbonated beverages and confectionery."

Certain features of the above resolutions may require some interpretation. Paragraph (2) refers to the addition of nutrients to be covered by definitions and standards promulgated under the Food, Drug, and Cosmetic Act. The purport and meaning of these definitions has already been discussed in Chapter III. Such definitions and standards exist only for a relatively small number of foodstuffs and it seems improbable that the majority of the very large number of foods in use, and especially those of a proprietary character, are ever going to be so defined and standardized. The Administrator, it will be recalled, is under obligation to issue such definitions and standards only if, in his judgment, honesty and fair-dealing in the interest of the consumer will be promoted thereby.

A food for which no standard has been promulgated and which is manufactured from two or more ingredients must carry on its label a list of the ingredients from which it is fabricated. A standarized food is not required to carry such an ingredient statement, but it is unlawful to add any ingredient which the standard does not specifically permit. The addition of vitamins or minerals to other foods is not prohibited by law so long as there is no conflict with general provisions of the act. The administrator is given broad authority to promulgate regulations for the efficient enforcement of the Food, Drug, and Cosmetic Act and specific reference is made to requirements for labeling of "foods for special dietary use." A food to which vitamins or minerals has been added to enhance its nutritive value is subject to these regulations irrespective of whether or not a standard has been promulgated for that food.

Paragraph (6) refers to a different class of foods, namely certain staples which the Board regards as in need of certain types of fortification in the interest of public health. Only as regards this limited list of foods is the Board disposed to advocate the use of synthetic treatments.

Paragraph (7) specifically opposes the addition of vitamins to carbonated beverages and confectionery. This is in conformity with the decision of the Board not to ratify the vitaminization of sugar even though it constitutes a large fraction of the average caloric intake. Sugar consumption in the United States amounts to about 100 pounds per capita per year, which is much larger than that of any other country. The reason for this adverse decision is the fear that the vitaminization of sugar and products composed essentially of sugar would lead to a further increase in their consumption to the detriment of health. The widespread belief that there is a relationship between sugar consumption and the incidence of dental caries was a factor influencing this decision. A more important consideration is the propensity, especially of children, to eat large amounts of sweet things and to consume considerable quantities of soft drinks between meals. They thus spoil their meal-time appetites for more wholesome foods which are necessary to provide a well-rounded nutrition.

The Food and Drug Administration has adopted a policy of essentially similar character to that above endorsed by the Food and Nutrition Board. It is stated as follows: [48]

> "STATEMENT OF POLICY OF THE FEDERAL SECURITY AGENCY UNDER THE FEDERAL FOOD, DRUG, AND COSMETIC ACT WITH RESPECT TO THE ADDITION OF NUTRITIVE INGREDIENTS TO FOODS
>
> "The labeling or advertising of a food as enriched with vitamins and minerals is an implied promise to consumers that it contains, in addition to the normal constituents of the unenriched food, sufficient vitamins and minerals to make a substantial contribution to the nutritional welfare of persons eating the enriched food in customary amounts. In order to promote honesty and fair dealing by fulfilling this implied promise, it is necessary that the kinds and quantities of enriching ingredients be determined in the light of deficiencies of the various nutritional factors in the diets of the population in general and of significant population groups, the place occupied by the food in such diets, and the suitability and effectiveness of the food as a carrier of the enriching ingredients without undue separation or loss before consumption.
>
> "Honesty and fair dealing will best be promoted if such enriched foods as are made available to consumers serve to correct such deficiencies and furnish a reasonable margin of safety. Enrichment above the levels required to accomplish this end is wasteful and contrary to the interest of most consumers; nutrient factors in concentrated form are available for use in those special cases of deficiencies in the diets of persons who do not constitute significant population groups. Enrichment of foods with nutrients that are supplied in adequate quantities by the diets of all significant population groups

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[48] Federal Register 8, 9170, July 3. See Appendix A-14.

is not only wasteful but tends to confuse consumers as to their nutritional needs.

"Knowledge of the roles in human nutrition of various components of food, particularly the vitamins, is incomplete. There is reason to believe that as new information is developed food factors not now recognized as essential may be shown to be necessary to adequate nutrition.

"Most natural foods contain a wide variety of needed factors in significant amounts. It is highly probable that a diet of unenriched foods so chosen as to contain the required quantities of the presently known needed vitamins and other factors would more nearly supply all needed factors, known and unknown, than a diet which is raised by enrichment to adequacy in the vitamins and minerals now known to be needed.

"Even though adequate nutrition could be better assured through the choice of natural foods than through reliance on enrichment, unenriched foods of the kinds and in the quantities necessary for adequate nutrition are not now available to substantial parts of the population and are not likely to be available soon; nor are most consumers sufficiently educated on nutritional questions to enable them to make an intelligent choice of combinations of unenriched foods on the basis of nutritional values.

"Because of the lack of adequate production of a number of foods high in certain nutrients and the lack of consumer knowledge of nutrition, appropriate enrichment of a few foods widely consumed by the population in general or by significant population groups will contribute substantially to the nutritional welfare of consumers and to meeting their expectations of benefit. Enrichment of those foods which are not a substantial part of the dietary of any significant group tends to confuse and mislead consumers through giving rise to conflicting claims of nutritional values and by creating an exaggerated impression of the benefits to be derived from the consumption of such foods.

"If the customary process of manufacturing a staple food refines it so as to remove significant quantities of nutritive factors present in the natural product from which the food is made, and if the refined food is a suitable and efficient carrier of the factors so removed, some nutritionists advocate the restoration of such factors to the levels of the natural product as the most desirable basis of enrichment. To the extent that restoration serves to correct deficiencies of such factors, it is consistent with the promotion of honesty and fair dealing that refined foods be enriched on a restoration basis. However, when the evidence shows that the restoration levels are too low to correct deficiencies, or that deficiencies exist in other factors for which the refined food is an efficient carrier, the promotion of honesty and fair dealing may require the inclusion of corrective quantities of nutritive factors in the enriched food even though such factors are present in smaller quantities or wholly lacking in the natural product from which the food is made. Similar considerations may require the enrichment of unrefined foods.

WATSON B. MILLER,
Acting Administrator."

MACARONI

The first type of product, other than flour, bread, and farina, to be considered for enrichment was the alimentary pastes, including macaroni, spaghetti, vermicelli, etc. Hearings were called by the Federal Security Administration to be held November 3, 1941, to consider definitions and standards of these products, not including enriched forms of them. Industry expressed its desire for enrichment standards but the government introduced testimony that such enrichment was not in the public interest. The Chairman of the Cereal Committee of the Board was empowered to present the Board's view on this question. The principal ground for seeking authority to enrich such products was the alleged need for enrichment nutrients on the part of special groups, notably those of Italian origin for whom these foods are traditional. However, from evidence collected and presented at the hearing, it appeared that the traditional Italian method of cooking of such products results in a substantial wastage of the added vitamins owing to their leaching out into the cooking water which is largely discarded. Particularly on this account the enrichment of these products was opposed by the Board through its agent at these hearings. The issue has been raised anew by the industry on the ground of additional evidence but the Board has not seen fit to reverse its former decision. Further investigation indicates that macaroni and the like range second to bread in furnishing calories to people of Italian origin. In addition, the consequences of the losses in cooking are now aggravated by the relatively scant supply of the various vitamins required.

RICE IMPROVEMENT

It was inevitable that white rice would become a candidate for enrichment. To a limited extent producers of rice in package form have adopted the practice of spraying the exterior with a vitamin solution, thus improving the nutrient value in a manner similar to that of the enrichment of flour. This practice has not been formally submitted to the Board for approval, and it is doubtful whether such a practice would be sanctioned. Owing to the prevalent custom of rinsing rice thoroughly before cooking there is considerable likelihood that the added nutrients will be lost before the rice is prepared for the table. Label warnings against preliminary rinsing are not likely to be generally observed. Certainly as regards rice sold in bulk such precautions could not be made effective.

Proposals have been made by at least two inventors that white rice grains should be impregnated with vitamin solutions and dried for shipment and sale. In order to avoid wetting and drying the whole of the rice, it is proposed that such treatment be applied to only a small portion of the total and that this highly fortified rice be mixed in suitable small proportion with the main mass. The treated rice is of unaltered appearance unless riboflavin is used; in that case the treated grains are prohibitively yellow. For thiamine and niacin such a practice has possibilities which seem worthy of consideration, at least for areas where rice is consumed in large amounts.

Rice is not a staple for the vast bulk of the American population. The average annual consumption amounts to only 5.2 pounds. In certain states, notably South Carolina and Louisiana, the average per capita consumption is 40 pounds per year, and in particular localities it may rise to 100 pounds. Rice consumption is highest in those areas where it is produced or where it once was grown in large amounts, as in the eastern part of South Carolina. In such regions there is ample justification for improvement of the nutritional quality of white rice. Perhaps it can best be cared for by state action rather than by a national movement in view of the non-uniformity of its use.

RICE CONVERSION

As in the case of wheat, retention of the natural vitamins of the grain in lieu of artificial fortification offers distinct possibilities, and perhaps is to be preferred. A process for achieving this result is the so-called "rice conversion process" operated at the present time by Mars & Harwell, at Houston, Texas. This process had its origin in a household practice traditional in certain parts of India, in accordance with which rice in paddy form is steeped in hot water and dried before milling. The effect of such steeping is to loosen the hulls so that they are removed much more readily, especially when milled by pounding in hand mortars. The bran coats tend to be removed less completely in the case of such parboiled rice than in rice which is milled in its initial dry state. However, much more important than this is the observation which first was made by W. R. Aykroyd,[49] that the entire grain is impregnated with the nutrients extracted by the steep water. In consequence, the vitamins originally in the bran coats are found to be fairly uniformly disseminated throughout the treated grain.

In the modern version of the parboiling process the impregnation of the grain is aided by the successive use of vacuum and hydraulic pressure so that a substantially better conservation of the nutrients can be achieved. According to M. C. Kik [50] the nutrient content of converted rice is typically as follows:

	Mgs. per pound
Thiamine	1.35
Riboflavin	0.18
Niacin	27.00

Converted rice tends to be somewhat yellowish in color in the raw state. This may somewhat handicap its sale. The color, however, is largely dissipated during cooking, so that the cooked product presents a barely discernible contrast to ordinary white rice. The conversion process confers a glazed surface on the grains which is of material aid in maintaining their shape when cooked and in avoiding stickiness of the mass. This feature will undoubtedly be very attractive to the majority of rice eaters. The glaze on the rice promises to be even more important to the rice miller. One of the largest costs involved in the milling of rice is the rather extensive breakage of the grains which occurs during milling. Converted rice mills with substantially less breakage. This is a distinct economic advantage to the miller as he must sell his broken grains at greatly reduced prices. Much of the broken rice is marketed as brewers' rice for beer production. The promoters of the process claim that the saving in breakage compensates for the cost of applying the conversion process. At present, facilities are available for the practice of conversion on only a tiny fraction of the annual rice crop and under present war conditions it seems unlikely that adequate facilities will become available for treating any large amount of rice. The process has undoubted merit but further experience will be required to establish the cost factors and the marketability of the product to the satisfaction of rice millers generally.

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[49] The effect of parboiling and milling on the antineuritic vitamin (B_1) and phosphate content of rice. Journal of Hygiene 32: 184 (1932).

[50] Cereal Chemistry 20: 563 (1943).

The original patents [51] are owned by Rice Conversion Limited, of London, which has plans to introduce the process into the large rice consuming areas of Asia where it will have a great usefulness if its commercial feasibility is demonstrated.

UNDERMILLING OF RICE

A more immediately available approach to the rice problem is that of undermilling. The commercial demand for rice under present war conditions is so keen that millers are most anxious to produce a maximum yield of salable rice. The buyer is also willing to accept rice of a poorer appearance and quality than he usually demands. The yield can be increased by undermilling, not only to the extent of the weight of the inner bran coats retained by the grain but also to a substantial degree by reducing breakage through shortening the milling process. Conditions are thus ideal for promotion of the production and sale of undermilled rice and the Food and Nutrition Board has considered it wise to encourage the adoption of this practice by the industry. If the public becomes habituated to a somewhat undermilled grade of rice it should facilitate its competitive sale in the future when more normal conditions are restored.

Several meetings have been held with groups of rice millers of the Rice Millers' Association and their representatives, who, in general, were found to be favorable to this course of action. One obstacle to the fostering of the sale and use of an undermilled grade of rice has been the lack of any standard for such a grade of rice established by the Grain Products Branch now connected with the War Food Administration. The establishment of such a standard was sought by the rice milling industry and the Food and Nutrition Board supported its petition. At a meeting of the rice milling industry held in New Orleans on December 4, 1943, consideration was given to the degree of milling which, in the judgment of the millers, would be required in order to make the rice marketable. Some tentative standards were arrived at by common agreement by selection from a series of samples milled to various degrees and analyzed by Dr. M. C. Kik, of the University of Arkansas Agricultural College, Fayetteville, Arkansas. Dr. Kik has collaborated extensively with the Board in collecting information about rice and rice milling and has made many contacts with the industry.

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[51] British No. 519,926 Apr. 10, 1940 to Erich Gustav Huzenlaub & John Heron Rogers.
British No. 522,353 June 17, 1940 to Erich Gustav Huzenlaub & John Heron Rogers.
U. S. No. 2,239,608 Apr. 22, 1941 to Erich Gustav Huzenlaub, et al.
U. S. No. 2,268,486 Dec. 20, 1941 to E. G. Huzenlaub.
U. S. No. 2,287,737 June 23, 1942 to Erich Gustav Huzenlaub & John Heron Rogers.

It developed at this meeting that the rice millers strongly favored the use of the term "unpolished" rather than "undermilled." It was also evident that in the opinion of rice millers the removal of a substantial part of the bran coats is necessary to make a marketable rice. It does not apear to be a simple matter to control the degree of milling to a precise vitamin content by process of visual inspection. However, in the belief of the rice millers and of Dr. W. D. Smith of the Grain Products Branch Inspection Service, with experience millers would be able to match selected samples fairly closely on appearance. Actual analysis of commercial samples will be necessary to determine how well this can be achieved.

Following this meeting with the rice millers, the whole subject was placed before the Food and Nutrition Board, which accepted the tentative standard selected from Dr. Kik's samples as a sufficient nutritional improvement over white rice to merit the Board's endorsement. Such a grade of unpolished rice is expected to compare in the freshly milled state with white rice as follows:

	Milligrams per pound	
Nutrient	Unpolished rice	White rice
Thiamine	0.8 to 1.0	0.3
Riboflavin	0.15	0.1
Niacin	12.	8.
Iron	5.	2.

In practice the miller will necessarily mill so as to retain the maximum amount of thiamine consistent with a suitable appearance of the rice and, incident thereto, accept the best that he can get with respect to the content of the other nutrients.

It is clear that the nutritional quality of such unpolished rice, while greatly superior to that of white rice, leaves much to be desired. Another shortcoming of unpolished rice is its questionable retention of thiamine during storage. Such meager data as are available indicate rather substantial losses in storage at summer temperatures and humidities. These data need confirmation. At the present time, however, an added reason for encouraging undermilling of rice is the better conservation of the food supply through increased yield of edible rice from a given quantity of rough rice.

On these grounds, representations were made to the War Food Administration in favor of the issuance of a standard for such a nutritionally improved rice. This standard, issued in March, 1944 and effective April 1, 1944, is stated in the following words:

> "Milled rice shall be whole or broken kernels of rice of the classes specified in these standards, from which, (a) in the case of milled rice other than milled rice of the special grade unpolished milled rice, the hulls and practically all of the germs and bran layers have been removed, or (b) in the case of milled rice of the special grade unpolished milled rice, the hulls and the outer bran layers, but not the inner bran layers, and a part of the germs, have been removed."

Obviously, this presents a rather vague definition from a compositional standpoint. However, the Grain Inspection Service is not equipped to perform elaborate analyses and must rely primarily upon visual inspection. Under these circumstances, a more definite description must await extensive operating experience.

In order to be consistent with the general anti-inflation policy of the government under present war conditions, the Office of Price Administration felt compelled to formulate price ceilings for unpolished or undermilled rice lower than those set for white or fully milled rice. The price range per 100 pounds for fully milled rice is $6.20 to $8.25; that for undermilled rice is $5.70 to $7.40. The lower price ceilings for the undermilled product are intended to adjust for the greater yield of rice produced. Many rice millers feel that the price ceiling differentials over-compensate for this factor and tend to discourage the production of unpolished rice. The facts are not clearly established and the Office of Price Administration has expressed itself as open to further evidence on the issue.

It will be clear from the above that the nutritional improvement of rice is at present in an experimental and developmental stage and it is too early to forecast its practical success.

CORN ENRICHMENT

Because of the prevalent relationship between the incidence of pellagra and the consumption of corn as a staple, the possible enrichment of corn meal and grits early engaged the attention of the Food and Nutrition Board. Corn is consumed as a staple commodity largely in the southern states and since it is the cheapest of all cereal products it tends to be used in lieu of wheat by low-income groups and in increasing proportions in hard times. Corn is by nature deficient in niacin, the whole grain usually containing 8 to 10 milligrams of niacin per pound, as compared with about 30 in wheat.

In the South as a whole, corn is consumed as meal and as grits. Most of the meal produced in the South is substantially whole corn meal from which only part of the outermost chaff-like membrane is removed. On the average, such corn meal constitutes half or more of the total corn consumption. In rural areas it may constitute almost the entire supply. In cities whole corn meal may fall to a much smaller proportion of the whole.

In addition to the home grown supply of corn products, a substantial amount of corn in forms prepared for human consumption is brought into the South principally from the corn belt region of the West. These imported corn products are almost entirely of the degerminated variety. Degerminated meal has a substantial advantage over the whole corn meal from the standpoint of stability in storage and this is of advantage for spring and summer consumption and for shippers who produce at a distance. There is a tendency for the local corn crop to be used up first and for imported degerminated products to succeed it toward the end of the season. Nearly all the grits consumed in the South are of the degerminated variety. There is a strong preference for white corn in the South and nearly all the corn used for human consumption, both locally grown and imported, is of that type.

Corn for human consumption constitutes, of course, only a very small fraction of the annual crop, the bulk of the corn produced being used for stock feeding. Accordingly, corn produced for human use constitutes a minor fraction of the corn industry as a whole. The corn coming into the South from the Middle West is almost entirely produced by a small number of relatively large millers. About thirty of them cover the bulk of the business. On the other hand, in the South the bulk of corn meal produced comes from small and often very small mills which in certain areas are encountered at almost every cross-roads. It is estimated that there are about 10,000 such corn mills in the South. Many of the millers operate only occasionally, as on rainy days or on Saturdays when the farmers come to town for their weekly shopping, bringing their corn to be ground at the mill. Toll milling is a very extensive practice.

Naturally, these two groups of millers have little in common. The larger mid-western millers do not encounter pellagra and have little sense of the local problem as it presents itself in the South. They make up the influential fraction of the National Corn Millers' Association which, of course, does not include the very large numbers of extremely small millers in rural areas. The sole incentive for enrichment for the big millers, therefore, is a preferred position for their products, especially in southern markets. A large fraction of their business is done in other areas where pellagra is not a recognized problem and much of their business is in the stock feed field. Operating as they do in higher priced labor areas, they feel the competition of the southern small miller very keenly and accuse him, not without some justice, of often producing a highly unsanitary product. Infestation with mice is naturally very prevalent around such mills unless rigorously controlled, and their droppings are likely to be included in the meal.

On account of these various factors, it has been very difficult to secure any unanimity of action among the corn millers. The small millers are hard to reach because of their numbers and remoteness and the large ones are without the incentive of an interest in the local problem. From a nutritional standpoint it is also essential that the whole corn meal and the degerminated products be treated differently. The former needs reinforcement with niacin and, to some extent, with iron, while the latter requires the addition of thiamine as well. Thiamine is the expensive ingredient of the enrichment formula. The method of approach to the small producers of whole corn meal must also be quite different from that of the approach to the large producers of corn products. The former are engaged largely in toll milling and put up their goods in almost any convenient receptacle, very often without the benefit of any label whatsoever. They must be appealed to almost entirely upon the basis of their public spirit in making a contribution to the nutrition of their community. The large millers, and especially those who put up their products in small package form, must be offered whatever competitive advantage enrichment labels supply.

ENRICHMENT OF WHOLE AND DEGERMED PRODUCTS

As a matter of practical necessity, different measures have been fixed by the Food and Nutrition Board as objectives in the case of the two types of corn products. For whole corn meal the present aim is a standard of 1.5 milligrams of thiamine, 16 milligrams of niacin, and 13 milligrams of iron per pound of meal. To achieve this, only the last two need be added. This involves little cost. To teach the small millers to use successfully the expensive thiamine seems prohibitively difficult. For degerminated products the aim should perhaps be the same as that for enriched flour, including thiamine, riboflavin, niacin, and iron, but to set such a standard would delay adoption of enrichment of whole corn products for many years. To require riboflavin only in the degermed products would put them at a great competitive disadvantage on costs. It has seemed more equitable to fix the same standard for degermed as for whole corn products. These "standards" are such only for the purposes of the Board's promotional efforts. No hearings have been held to fix official standards, and the industry has evinced no eagerness for such hearings. Without the interested collaboration of industry the promulgation of federal definitions and standards would be of little avail since they have only a permissive character. In any case, such standards would not directly affect the great bulk of whole corn meal production, as it does not enter into interstate commerce. The course of the Board has, accordingly, been to foster an interest in the matter upon the part of the larger corn millers in the hope that competitive interest will arise. As for the small corn millers, South Carolina is making an extensive effort through the agency of Clemson Agricultural College and with the aid of funds provided by Research Corporation to propagandize the small millers, acquainting them with the merits of enrichment, supplying them with enrichment mixtures and labels, and fostering the public demand for the enriched products through educational processes.

In addition, South Carolina, Alabama, and Mississippi have passed laws making mandatory the enrichment of degerminated corn products. These laws have caused considerable controversy and it has been necessary to postpone the original effective date in South Carolina. According to plan, mandatory enrichment of degerminated corn products is to become effective in these three states on February 1, 1945, but the requirements are unfortunately not uniform in the three states. The wide-spread shortage of corn products for human consumption incident to war conditions has been a powerful weapon in the hands of those large corn millers who were unready for general corn enrichment and particularly for legislation to that effect. On the other hand, indefinite procrastination might have been encountered if the other course had been chosen. Each southern state considering enrichment legislation should give careful thought to the question as to whether or not enrichment of degerminated corn products should be required simultaneously with mandatory enrichment of bread and flour. On the one hand, there is a temptation to take care of the whole matter at once and avoid the labor of fathering corn enrichment legislation at a later time. On the other hand, opposition to corn enrichment may in some areas imperil the passage of bread and flour enrichment if bread, flour, and corn enrichment are incorporated in the same bill.

The enrichment of grits presents a special problem. Superficial application of nutrients is likely to result in loss of the nutrients in rinsing before cooking. Rinsing is a general, though not universal, practice. South Carolina requires resistance to loss by rinsing. Alabama and Mississippi merely require a warning against rinsing on the label of enriched grits. The South Carolina requirement can be met by mixing with the grits fragments of a highly fortified macaroni-like product.

For the South corn products enrichment is an essential part of the enrichment program. Pellagra cannot be eradicated without the enrichment of corn as well as wheat products. Intelligent wheat millers, especially if they are also corn millers, will lend their heartiest support to corn products enrichment. Without the complete eradication of pellagra the enrichment program can never be accounted a complete success in the eyes of the American public.

BREAKFAST CEREALS

As a part of its program for extending public education in the choice and use of foods for better nutrition, the Office of Defense Health and Welfare Service allowed producers of approved food products to use the insignia of the Office in advertising matter. The privilege of the use of this insignia in participation in the national nutrition program came to be coveted by food industries in general. Accordingly, a large number of applications were received by the Office for a part in the program. For this purpose the Office exercises a scrutiny of the advertising copy and particularly of the food product advertised. Among the products seeking such recognition under the national nutrition program were numerous prepared cereals, commonly referred to as breakfast cereals. As some such cereals are made from whole grains, others from refined grains, and still others are of intermediate character, the Office considered it necessary to adopt some standard of nutritional excellence and sought the advice of the Food and Nutrition Board on April 27, 1942. In harmony with the previous decision of the Office that only whole grain and equivalently enriched cereal products were to be included in the program, particular advice was wanted as to what should be considered a whole grain cereal for this purpose. To this request for advice the Board authorized the following reply, which is quoted in its final form as adopted November 15, 1942:

> "STATEMENT OF PRINCIPLE CONCERNING BREAKFAST FOOD CEREALS AND AMOUNTS OF CERTAIN NUTRIENTS (Suggested for Cereals Restored in Thiamine, Niacin and Iron).
>
> "The Food and Nutrition Board of the National Research Council include under the term 'whole grain cereal products' nutritionally unimpaired grain products which contain their natural proportions of bran, germ and endosperm. The Board feels that in addition to such whole grain cereals, certain other 'breakfast' cereals are deserving of a place in the National Nutrition Program.
>
> "The Board favors every practicable effort to retain all natural nutrients, especially thiamine, niacin and iron in the processing of cereals. When, after satisfactory study, it becomes apparent that loss of such important nutrients is unavoidable, their restoration to whole grain levels is desirable.
>
> "Products suitably restored should be included in the National Nutrition Program, but should be referred to as 'cereals restored in thiamine, niacin and iron' with the understanding that restoration for the present includes thiamine, niacin and iron.
>
> "*Supplementary Notes to Statement of Principle on Breakfast Food Cereals:* It is the belief of the Committee on Cereals and of the Board that for the purposes of the National Nutrition Program this resolution provides a basis for answering the specific questions in your letter:
>
> "1. A whole grain cereal product is defined as a grain product which is nutritionally unimpaired, i.e., which has retained the specific nutrients of the whole unprocessed grain, and which furthermore contains the natural proportion of bran, germ and endosperm.
>
> "2-3. A cereal food made from the natural proportions of bran, germ and endosperm but which has suffered substantial loss of one or more of its important nutrients in processing should not be considered a whole grain cereal product, and it should not be considered worthy of inclusion among the preferred foods in the National Nutrition Program. However, if the loss sustained in processing is corrected by either improved methods of processing or by restoration of the lost nutrients, such product would be worthy of consideration in the National Nutrition Program, provided that in the representations concerning the latter type of food it is described as 'a whole grain cereal restored in thiamine, niacin and iron.'

"Cereal foods containing bran, germ and endosperm in other than natural proportions may also be included in the National Nutrition Program if the thiamine, niacin and iron levels of the product fall within the range of values, as defined below, characteristic of the whole cereal from which it is made. Representation of such cereals may refer to the products as 'cereals restored in thiamine, niacin and iron.'

"4. The principle applicable to a cereal product made from a mixture of cereal grains differs from the above only in that the nutritive levels should represent the weighted average of the component grains.

"5. According to the resolution, special attention should be given at this time to the content of thiamine, niacin and iron. Later, as knowledge increases and as methods develop which permit control of other nutrients, additional nutrients may need to be considered.

" 'For the purposes of determining eligibility for inclusion in the National Nutrition Program, the following ranges of values of each of the nutrients in each of the grains shall be considered as acceptable compliance with the whole grain levels. These ranges have been selected after study of all available, reliable data and other consideration of the fact that there is a considerable natural variation of the level of each of these nutrients in each of the grains dependent upon season, variety, soil, climatic conditions, etc. The ranges are chosen so as to exclude only inferior grades of each grain and a few exceptionally high values. They therefore represent practically attainable values in round numbers rather than means or averages obtained mathematically.

"AMOUNTS OF CERTAIN NUTRIENTS SUGGESTED FOR CEREALS RESTORED IN THIAMINE, NIACIN AND IRON

	THIAMINE mg. per pound	NIACIN mg. per pound	IRON mg. per pound
Wheat	2.0–3.0	24–36	16–24
Oats	3.0–4.0	4–8	12–24
Rice	1.5–2.5	20–30	10–20
Corn	1.7–2.6	8–12	6–15

"It is expected there may be occasionally questions upon which you would like further advice. The Committee on Cereals and the Food and Nutrition Board stand ready at all times to give you all possible assistance.

ADOPTED NOVEMBER 15, 1942."

The discussion of this subject in the Food and Nutrition Board clearly reveals that the fortification of breakfast cereals in the foregoing manner is a practice which the Board wishes to permit rather than promote. Many expressions of Board members were to the effect that whole grain cereals in the above designated sense represented a nutritional improvement over the refined varieties. However, the use of such breakfast cereals is not sufficiently extensive to bring them within the category of staple foods the enrichment of which is regarded as essential to betterment of national nutrition. The possibility may arise that such breakfast cereals may come up for consideration for the adoption of definitions and standards under the Food, Drug, and Cosmetic Act. In that case the Food and Nutrition Board will be faced with its previous resolution of October 1, 1941, limiting its advocacy of enrichment to certain staples. (See Chapter XIII, page 89.) Under that resolution the Board is committed to opposing the adoption of standards and definitions for such a fortified cereal.

One cereal product which came up for such a definition before the inception of the enrichment program is farina. It is often classed as a breakfast cereal and the adoption of a definition for enriched farina may stand as a future embarrassing precedent. (See Chapter III, pages 16-17.)

A fortification which the Food and Nutrition Board has vigorously advocated is the addition of vitamin A to oleomargarine, as well as the addition of vitamin D to milk. The extent of advocacy by the Board of these fortifications has been much less than that of the enrichment of bread and flour. Both such fortifications began to be practiced before the origin of the Board. However, fortification of milk with vitamin D has never affected more than a small fraction of the total milk output. It has achieved importance almost entirely in connection with milk used in the feeding of growing children. Fortification of oleomargarine with vitamin A has, on the other hand, become very general in recent years, though it has been vigorously opposed in some areas. State legislation requiring the fortification of oleomargarine has been passed by several southern states, as discussed in Chapter IX, pages 58-59.

APPENDIX A

FEDERAL SECURITY AGENCY ACTIONS RELATING TO ENRICHMENT

1. Notice of public hearing on October 7, 1940, on proposed regulations regarding label statements concerning dietary properties of food. Federal Register *5*, 3565-3566, September 5, 1940.
2. Notice of public hearings on September 4, 1940, for purpose of promulgating definitions and standards of identity of certain foods. Federal Register *5*, 2746-49, August 3, 1940.

   Notice of reconvention on November 12, 1940, of hearings which commenced on September 9, 1940, on definition and standard of identity for each of the following foods: (A) flour, white flour, wheat flour, plain flour; (B) durum flour; (C) whole wheat flour, graham flour, entire wheat flour; (D) cracked wheat; (E) crushed wheat; (F) whole durum wheat flour; (G) self-rising, self-rising white flour, self-rising wheat flour; (H) phosphated flour, phosphated white flour, phosphated wheat flour; (I) farina; and (J) semolina. Federal Register *5*, 4057, October 11, 1940.
3. Proposed standards of identity of flour, enriched flour, bromated flour, enriched bromated flour, self-rising flour, enriched self-rising flour—farina, enriched farina and semolina. Federal Register *6*, 1729-1737, April 1, 1941.
4. Final Order of a definition and standard of identity for (A) flour . . . .; (B) enriched flour; (C) bromated flour; (D) enriched bromated flour; (E) durum flour; (F) self-rising flour . . . .; (G) enriched self-rising flour . . . .; (N) farina; (O) enriched farina; (P) semolina. Dated May 26, 1941. Effective date January 1, 1942. Federal Register *6*, 2574-2582, May 27, 1941.
5. Notice of Hearing on July 7, 1941, in the matter of a definition and standard of identity for various breads. Dated June 5, 1941. Federal Register 6, 2771-2774, June 7, 1941.
6. Proposed regulations regarding label statements concerning dietary properties of food purporting to be or represented for special dietary uses. Federal Register *6*, 3304-3310, July 8, 1941.
7. Final Order Regarding Label Statements on Food for special dietary use. Dated November 18, 1941. Federal Register *6*, 5921, November 22, 1941.

   Correction of above. Federal Register *6*, 5951, November 25, 1941.

   Further correction of above. Federal Register *6*, 6176, December 3, 1941.
8. Order postponing till July 1, 1942, the effective date of requirement of the ingredient riboflavin in enriched flour, etc. Dated November 29, 1941. Federal Register *6*, 6175-6176, December 3, 1941.
9. Minor correction of above order. Federal Register *6*, 6256, December 5, 1941.
10. Order further postponing riboflavin requirement in enriched flour to April 20, 1943. Federal Register *7*, 3055, April 25, 1942.

    Further postponement of riboflavin requirement to October 1, 1943. Federal Register *8*, 3358, March 19, 1943.
11. Notice of hearings on definition and standard of identity of macaroni, etc. Federal Register *6*, 4481, August 29, 1941.

    Postponement of above hearings. Federal Register *6*, 4893, September 25, 1941.

    Further postponement of above hearings to November 3, 1941, and amendment of notice. Federal Register *6*, 5050, October 3, 1941.

    Proposed order fixing a definition and standard of identity for macaroni, etc. Federal Register *7*, 10728-10734, December 22, 1942.
12. Notice of Hearing April 19, 1943, concerning definitions and standards of enriched flours, enriched breads and enriched farina. Dated March 17, 1943. Federal Register *8*, 3378-3379, March 19, 1943.
13. Proposed order amending definitions and standards of identity of enriched flours and farina. Dated June 4, 1943. Federal Register *8*, 7511-7514, June 5, 1943.

14. Statement of policy with respect to the addition of nutritive ingredients to foods. Dated July 1, 1943. Federal Register *8*, 9170, July 3, 1943.
15. Order amending definitions and standards of identity of wheat flour and related products. Dated July 1, 1943. New levels of enrichment are prescribed to take effect October 1, 1943, as follows:

For enriched varieties of flour

	minimum	maximum	Mgs. per pound
Thiamine	2.0	2.5	" " "
Riboflavin	1.2	1.5	" " "
Niacin	16.0	20.0	" " "
Iron	13.0	16.5	" " "
Calcium* †	500	625	" " "
Vitamin D (not changed)**	250	1000	U. S. P. units

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* Required in self-rising flour, min. 500 mgs., max. 1500 mgs., per lb.

**Optional.

† Optional in all flours except self-rising.

Federal Register *8*, 9115-9116, July 3, 1943.

16. Proposed order on definitions and standards of identity of various kinds of bread. Dated July 29, 1943. Federal Register *8*, 10780-10788, August 3, 1943.

Enriched bread shall contain

	minimum	maximum	Mgs. per pound
Thiamine	1.1	1.8	" " "
Riboflavin	0.7	1.6	" " "
Niacin	10.0	15.0	" " "
Iron	8.0	12.5	" " "
Vitamin D	150	750	U. S. P. units (optional)
Calcium	300	800	Mgs. per pound (optional)

APPENDIX B

WAR AGENCY ACTIONS ON ENRICHMENT

1. Food Distribution Administration, Food Distribution Order 1 Bakery Products—manufacture and sale of bread and rolls, issued December 29, 1942, effective January 18, 1943. Federal Register *7*, 11105, December 31, 1942.
2. FDO 1, Amdt. 1, Bakery Products—maufacture and sale of bread and rolls, issued January 13, 1943. Federal Register *8*, 828, January 19, 1943.
3. FDO 1, Amdt. 2, Bakery Products—manufacture and sale of bread and rolls, issued January 25, 1943. Federal Register *8*, 1177, January 27, 1943.
4. FDO 1, Amdt. 3, Part 1404, Bakery Products—manufacture and sale of bread and rolls, issued March 6, 1943, effective March 6, 1943. Federal Register *8*, 2913, March 10, 1943.
5. FDO 1, Amdt. 4, Bakery Products—manufacture and sale of bread and rolls, issued June 17, 1943, effective July 1, 1943. Federal Register *8*, 8387, June 19, 1943.
6. FDO 1, Amdt. 5, Bakery Products—manufacture and distribution of bakery products, issued December 11, 1943, effective January 16, 1944. Federal Register *8*, 16777, December 15, 1943.
7. FDO 1, Amdt. 6, Bakery Products—manufacture and distribution of bakery products, issued January 13, 1944, effective January 16, 1944. Federal Register *9*, 599, January 15, 1944.
8. FDO 1-1, War Food Administration, Distribution Orders—Bakery Products—furnishing of equipment, issued January 17, 1944, effective January 18, 1944. Federal Register *9*, 778, January 21, 1944.
9. War Food Administration, Redesignation and Renumbering of Orders
    1. The Food Production Orders, the Food Distribution Orders, the Commodity Credit Orders, the Food Directives, and all Regulations listed in Column A below, including all amendments thereto, shall hereafter be known as War Food Orders and are hereby assigned the War Food Order numbers indicated in column B below:

A	*B—War Food Order No.*
FDO 1	1

Federal Register *9*, 4319, April 22, 1933.

10. War Food Administration (Distribution Orders). WFO 1, Amdt. 1, Bakery Products—enrichment of white bread and rolls, issued April 25, 1944, effective May 1, 1944. Federal Register *9*, 4527, April 29, 1944.
11. Food Distribution Administration, FDO 10—Rice—sale and distribution (covers rough rice, brown rice, milled rice, and undermilled rice), issued January 21, 1943, effective January 22, 1943. Federal Register *8*, 1076, January 23, 1943.
12. WFO 10, Amdt. 4—Rice—changing definitions on milled and undermilled rice, issued May 13, 1944, effective May 15, 1944. Federal Register *9*, 5289, May 18, 1944.
13. Office of Price Administration—Food and Food Products, Rev. MPR 150, Amdt. 3—Finished Rice and Rice Milling By-Products—price ceilings given, including undermilled rice, issued October 14, 1943, effective October 20, 1943. Federal Register *8*, 14076, October 16, 1943.

APPENDIX C

RESOLUTIONS AND ACTIONS OF THE FOOD AND NUTRITION BOARD OF NATIONAL RESEARCH COUNCIL

November 26, 1940

MOVED: That the amounts of thiamine, nicotine acid and other nutrients recommended by the subcommittee on Medical Nutrition, endorsed by the Council on Food and Nutrition of the American Medical Association, and presented in the testimony before the Food and Drug Hearings, November 14, 1940, by Wilder, Sebrell, Jolliffe and Williams, be endorsed by this Committee. Adopted.

MOVED: That the Chairman appoint a subcommittee on definitions and standards for nutritionally satisfactory staple foods with special reference to bread, and that this subcommittee report back recommendations for a nutritionally satisfactory bread before the time of public hearings on bread by the Food and Drug Administration. Adopted.

January 29, 1941. Press Release

Committee of National Research Council urges millers and bakers to produce vitamin-enriched flour and bread immediately; agreement on specifications and name reached; Food and Drug Definition expected shortly.

Washington, January 29. The National Research Council's Committee on Food and Nutrition announces here today that it has urged the millers and bakers of the Nation to start early production of a new flour and bread enriched in vitamins and minerals. The millers and bakers have agreed to start production without delay. Of necessity, it will be several weeks before the new flour and bread will be generally available.

The new flour (and bread) will be called "enriched." It will contain thiamine (vitamin B_1), iron and the pellagra-preventing factor, nicotinic acid, in amounts approximating those found in wheat. The name and the standards were decided on by conferences of National nutrition authorities, including the Committee on Food and Nutrition of the National Research Council, the Council on Food and Nutrition of the American Medical Association, Government nutrition experts, and representatives of the milling and baking industries. The U. S. Food and Drug Administration is at present working on regulations relating to the new flour and bread and will announce its rulings later. The name and standards already agreed on in conference, however, are sufficiently close to those that the Food and Drug Administration has had under consideration for flour that millers and bakers can start production without waiting for official action.

The need for early action in production of "enriched flour" and "enriched bread" is emphasized by the defense emergency. There is ample reason to believe that any population receiving a diet fully adequate in vitamins, minerals, and other nutritive essentials is better able to withstand the stresses and strains of war or threats of war. Unquestionably millions of Americans are not eating diets adequate in all essentials. The general use of "enriched flour" and "enriched bread" will materially improve the diet of the American people in this respect.

"Enriched flour" will contain thiamine, nicotinic acid, and iron in amounts corresponding to or even greater than those in stone-ground flour from high vitamin quality wheat.

"Enriched bread" may be made from "enriched flour" or by the addition of the required vitamins and iron to the baker's formulas, or by the use of special yeasts.

"Enriched flour" can be made in either of two ways. One way involves a change in milling processes. This will give flour of a rich creamy color and palatable flavor with a large proportion of the vitamins and minerals of the wheat with but little of the bran. It is expected that this method when fully developed will not add to the price of either bread or flour. The other way is to add the proper amounts of thiamine, nicotinic acid and iron to white flour. The color and baking qualities of such flour will be unchanged.

The cost of this enrichment should not be more than 50 cents per barrel of flour, or about three cents for a 12-pound sack. To produce a pound loaf of "enriched bread" will cost less than two-tenths of a cent more than to produce ordinary white bread, and it is believed in the end will involve no extra cost to the consumer.

It is not to be supposed that eating only a slice or two a day of the new bread could have much effect on the adequacy of the diet. The Committee emphasizes the special importance of the "enriched flour" and "enriched bread" for those who depend on bread for a large part of their energy food.

The Committee further urges consumers to purchase "enriched flour" and "enriched bread" in preference to types of flour and bread which fail to provide the specified amounts of the nutritional factors named.

May 24, 1941

MOVED: That because of the importance of an adequate supply of vitamins for the maintenance of good health, morale, and physical efficiency, it is urgently recommended that priority rating be granted for the manufacture of synthetic vitamins. Present manufacturing facilities are not adequate to meet the needs (1) for shipment to Britain and Canada, (2) for the health program of "enriched flour and bread" that has been launched on a national scale, and (3) to meet the current demands in medical practice. Each of these three requirements is of such importance as to demand appropriate consideration in the national defense program, and the Chairman is instructed to transmit this recommendation to the Office of Production Management. Adopted.

MOVED: That the report of the Subcommittee, including specifically the recommendation that for purposes of labeling, the use of the word "Enriched" in the name of a food should be limited to flour and bread as these are defined in S.R.A.F.D. No. 2, Rev. 5, Nov. 1936 be accepted. Adopted.

. . . . .

MOVED: That the Committee on Food and Nutrition approve undertaking an active study of the problem presented by rice and empower Dr. Williams' subcommittee to solicit funds, select personnel and provide the leadership for this project. Adopted.

June 21, 1941

MOVED: That the following resolution be transmitted to the Coordinator of Health, Welfare, and Related Defense Activities:

RESOLVED: That the addition of vitamin A to oleomargarine as permitted by paragraph 6 of the Regulations of the Food and Drug Administration, promulgated in the Federal Register June 7, 1941, is in the interests of better nutrition, particularly of low-income groups and, therefore, is fully approved by this Committee; that such additions of vitamin A are available; further, that every effort should be made to obtain the supplies of vitamin A necessary for this purpose. Adopted.

. . . . .

MOVED: That the figure for the required ingredient riboflavin in bread be set at 0.6 milligrams per pound; permissible maximum at 1.2 milligrams per pound. Adopted.

. . . . .

MOVED: That the following figures for the required and optional vitamin and mineral ingredients for "enriched" bread be adopted as the recommendations of the Committee on Food and Nutrition:

Per Pound of Bread

	Minimum	Maximum
Thiamine (required)	1.1 mgs.	2.2 mgs.
Riboflavin (required)	0.6 mgs.	1.2 mgs.
Nicotinic Acid or Nicotinic Acid Amide (required)	10. mgs.	20. mgs.
Iron (required)	8. mgs.	16. mgs.
Calcium (optional)	300 mgs.	1200 mgs.
Vitamin D (optional)	150 U.S.P. units	600 U.S.P. units

Adopted

MOVED: That Dr. Wilder and Dr. Williams be authorized to represent the Committee at the public hearings on bread and to present in the testimony taken at those hearings the recommendations of the Committee in the matter of vitamin and mineral content of "enriched" bread. Adopted.

July 27, 1941

MOVED: That the Committee on Food and Nutrition of the National Research Council recommends that general widespread use of iodized salt be encouraged; that all iodized salt be standardized for the present at a level of 0.01 percent potassium iodide or its equivalent and that the manufacturers of iodized salt be urged to continue their cooperation in this voluntary contribution to the public health. Adopted.

September 4, 1941

Summary of Results of Questionnaire on Enrichment Policy, quoted in Chapter XIII, pages 88-89.

October 1, 1941. Report of Subcommittee on Fats

The question of the fortification of foods with vitamin A is deemed worthy of consideration because of the importance of this vitamin and because some evidence exists that there is a deficiency of vitamin A in the diet of the American people. Should any foods be so fortified, it would seem proper to limit such fortification to fats and oils, some of which are important natural food sources of this vitamin. Those fats which, like oleomargarine, are consumed as substitutes for butter as spreads for bread properly may be fortified, and the Committee already has approved this step as desirable for the improvement of the diet of low-income groups. Other fats and oils are used for many purposes, as salad oils, for baking, deep-fat and pan frying, and the like. While the data are relatively meager, and suggest the need for further study, the evidence indicates that the vitamin A contained in fats used for certain of the above purposes is subject to considerable destruction, which would mean a substantial wastage of any vitamin A added to these products. On the basis of the present evidence, therefore, the Subcommittee believes that the fortification of fats and oils (other than table fats as mentioned above) is not in the interest of improved nutrition, and recommends that such fortification be discouraged. The Subcommittee recognizes that natural vegetable sources of provitamin A are available and cheap and that a greater consumption of these foods would solve the problem of inadequate intake of vitamin A, even in the low-income groups, and it is believed that more emphasis should be placed on the educational and other means of bringing about this solution."

. . . . .

October 1, 1941

Resolution relating to addition of specific nutrients to foods. Quoted in full in Chapter XIII, page 89.

December 17, 1941

MOVED: That the Deputy Director Assistant in charge of nutrition in the Office of Defense Health and Welfare Services be informed: that the Board is not prepared to take action at present on the recommendation concerning enrichment of sugars, but is submitting that recommendation to the Committee on Cereals. Rice and Sugar for consideration, with the recommendation that such consideration should take into account (1) the resolution on enrichment adopted by the Committee on Food and Nutrition (on October 1, 1941) (2) the desirability of waiting before taking action on sugar until the Board has obtained further experience in the enrichment of flour, also until the Board is satisfied that no difficulty would be created in the flour program such as might arise from (a) shortages in the supply of thiamine and other vitamins which might be added to sugar (b) creating the prejudice in the minds of people whom the Board is trying to convince of the desirability of improving white flour, that the Board is going too far at present in the fortification of foods in general. That the results of the poll of the members of the Board be communicated to the Committee on Cereals, Rice and Sugar. Adopted.

February 14-15, 1942

This Committee's name was changed—
from—Committee on Cereals, Rice and Sugar
to—Committee on Cereals.

Its members are Dr. Williams (Chairman), Messrs. Gunderson, Nelson, Patterson, Sebrell, Thomas and Wilder.

Dr. Williams reported that the Army and Navy had recently announced enriched flour and enriched bread will now supplant all non-enriched flour and bread for those services. The Enriched Bread and Enriched Flour Hearings would probably be reopened *simultaneously* to eliminate discrepancies; date of further hearings is not yet announced. The Board voiced its willingness to express an opinion; as, for example, in the instance in behalf of South Carolina state legislation requiring enrichment of flour and bread. After thorough discussion, the Executive Committee agreed that members of Dr. Williams' Committee on Cereals might appear before state legislative committees in support of the enriched flour and enriched bread. In that event, requests for such aid should be addressed to the Food and Nutrition Board of the National Research Council, and would be referred to Board Chairman Boudreau and Committee Chairman Williams.

May 4-5, 1942

Resolution concerning extension of the program for enrichment of white flour and bread:

The Food and Nutrition Board of the National Research Council reaffirms, in the interest of improved nutrition, its endorsement of the enrichment of all family white flour and all bread with thiamine, niacin and iron.

While enriched flour is generally available to consumers throughout the country, there are still many areas in which flour in the lower priced grades, which are the grades chiefly used, is not enriched. There are many localities in which enriched bread is not available.

In the interest of extending the benefits of enriched flour and bread to the entire nation, the Food and Nutrition Board of the National Research Council strongly urges the universal enrichment of all grades and types of white flour and bread.

The Board recommends the accomplishment of this objective at the earliest possible date; and earnestly solicits the cooperation of the millers, the bakers, all educational organizations, the distributors and consumers.

To this end we bespeak also the active participation of the office of Defense Health and Welfare Services and all federal and state agencies cooperating in the nutrition program.

Statement of Principle on breakfast food cereals (preliminary) see below, November 15, 1942, also Chapter XIII, pages 101-102.

June 7, 1942

It is recommended to the Executive Committee of the Food and Nutrition Board that the following resolution be transmitted to the Administrator of the Federal Security Agency:

WHEREAS, the present minimum of 6 milligrams of niacin per pound of enriched flour is, in the light of recently acquired knowledge, insufficient to have a marked effect upon the incidence of pellagra in the United States, and

WHEREAS, the extension of the use of enriched flour is now progressing rapidly, especially in the South, under the stimulus of educational work of the office of Defense Health and Welfare Services, and associated nutritionists, and of millers supplying flour to the South, and is being further promoted by legislative enactment in South Carolina, and legislative proposals in Louisiana, thus creating an extremely favorable opportunity for the extensive eradication of pellagra, and

WHEREAS, the present low minimum level of niacin in enriched flour is in our judgment destined to bring disappointment to those concerned with the eradication of pellagra, and thus to cast discredit upon the entire bread and flour enrichment program, and

WHEREAS, it further seems desirable shortly to attempt the enrichment of corn meal along similar lines, and primarily for the purpose of further lowering the incidence of pellagra, and

WHEREAS, the enrichment of bread and flours throughout the country will be facilitated by early removal of uncertainties concerning other pending modifications of the standard for enriched flour;

BE IT RESOLVED, that the Administrator is hereby urged to cause the calling of further flour and bread hearings at the earliest convenient time, to the end that new testimony may be presented which will permit "adjustment of the present standards for enriched flour, and hasten the setting up of an enriched bread standard." Adopted, subject to further discussion . . . with milling industry.

. . . . .

MOVED: That the Cereal Committee be authorized to ask the flour millers, through the Millers' National Federation, to make voluntary niacin increases from 4 to about 16 milligrams per pound in all of their self-rising and phosphated flour as early as that Committee is satisfied as to the propriety of such action. Adopted.

. . . . .

MOVED: That the Chairman, in the interest of the enrichment program, transmit to each of the manufacturers of thiamine and to Mr. Poillon of the Research Corporation, a message expressing great appreciation for all they have done to bring down the cost of thiamine and the desirability of reducing the price to still lower levels. Adopted.

September 12, 1942

BE IT RESOLVED, that the following statement be sent to appropriate representatives of the baking industry:

> "Whole wheat bread and so-called mixed breads in which other products, such as whole wheat flour, cracked wheat flour, rye flour, soya flour, or peanut flour, do not conform with the definition for 'enriched bread' adopted by the Food and Nutrition Board. Representations made for such products should neither state nor imply that they are 'enriched bread.' This should not be interpreted as discouraging the use of enriching ingredients or enriched flour in the manufacture of mixed breads, or as prohibiting truthful statements about such products."

The resolution was adopted by a vote of 16 to 10 with the proviso that when used it be accompanied by a carefully considered explanatory statement.

Such an explanatory statement is incorporated in the minutes for the information of the Board, as follows:

> "The Food and Nutrition Board regards whole wheat bread and breads made of mixtures of flours as a wholesome and meritorious class of foods, the use of which should be encouraged, provided the nutrient values lie in the range of normal whole wheat bread or of enriched bread. Withholding of the use of the name 'enriched' as applied to this class of breads, as in the accompanying resolution, should not be construed as any disparagement of this class of breads. The purpose of the resolution is rather to point out the limitations of the legal meaning of the word 'enriched.' The resolution has a technical content and purpose which would not be readily understood by the public, and is not intended to be transmitted to the popular press.
>
> "The legal meaning of 'enriched' is based on definitions and standards promulgated and proposed by the Federal Security Administrator. 'Enriched flour' is defined, Federal Register, May 27, 1941, page 2579, as conforming to the definition and standard of identity of 'flour' which in turn is characterized by the fact that it 'is freed from bran coat or bran coat and germ to such an extent that

the per cent of ash therein—is not more than the sum of 1/20 of the per cent of protein therein—and 0.35.' This means that the product containing more than the above proportion of ash cannot be designated either as 'flour' or as 'enriched flour.' This definition of flour by ash limitation has the sanction of long acceptance in milling practice and in food law enforcement.

"There is no corresponding standard at the present time for 'enriched bread.' However, such a standard was proposed by the Federal Security Agency in the Bread Hearings which were held in July and August, 1941. According to these proposals, 'bread,' 'white bread,' and 'enriched bread' were alike defined as products made from 'flour' as above described. These definitions were unopposed by any testimony at the Hearings and it must accordingly be anticipated that they will ultimately be adopted. The baking industry has been operating for more than a year past on a gentleman's understanding with the Food and Nutrition Board and the Federal Security Agency that the above proposed definitions of bread will be observed in the production of enriched bread as if they were in full force and effect. However, some bakers, evidently misunderstanding the situation, are reported to be labeling various mixed breads as 'enriched'. Other bakers feel that they are put at a disadvantage by their conscientious adherence to the commitments of the industry.

"The above cited definition of enriched flour and the proposed definition of enriched bread do not prescribe the method by which the required levels of thiamine, niacin and iron shall be achieved. Enriched flour may be produced by the addition of synthetics or by the retention of the natural nutrients of the grain, but in either case the ash limitation must be met. In effect the same ash limitation carries over to the proposed definition for enriched bread.

"Since mixed breads as above discussed, as well as whole wheat bread, are made in whole or in part from flours which do not conform to the above ash limitation, it is constructively illegal to refer to them as enriched breads.

"The question as to why the Federal Security Agency proposed and adopted such a definition for flour involves a long industrial and legal history which cannot be discussed briefly. However, general principles of law require the Federal Security Administrator to respect the common and accepted usage of terms in the industry in his formulation of definitions and standards of identity.

"Vendors of mixed breads are entitled to make truthful statements with regard to the nutritive quality of their products and may even state that they conform with respect to the thiamine, niacin and iron to the standards for enriched bread, provided the statement does not appear in such a manner as to imply that they are 'enriched breads'."

November 15, 1942

Statement of Principle concerning Breakfast Food Cereals. Quoted in full, Chapter XIII, pages 101-102.

January 14-16, 1943

The Food and Nutrition Board recommends that special priorities be immediately established which will assure allocation of sufficient dry skimmilk solids to permit universal compliance with Food Distribution Order No. 1; and, in conference with the Secretary's comments as related in the news release of the Office of War Information for December 30, 1942, relating to Food Distribution Order No. 1, that this Order be amended as soon as the skimmilk solids become available to require that all white *pan* bread contain not less than 6 parts of skimmilk solids to 100 parts of flour; and, furthermore, in order to increase the acceptability of bread that the maximum permitted percentage of sugar be raised to 6 and of shortening to 4 as soon as supplies are adequate. Adopted.

. . . . .

WHEREAS, the nation has a relative abundance of wheat and corn for human consumption but is subject to certain restrictions as to the civilian use of some types of foods due to the war needs of our troops and civil and military needs of our allies;

WHEREAS, the Food and Nutrition Board of the National Research Council believes that under these circumstances the achievement and maintenance of maximum nutritional quality in bread, flour, corn meal and grits are of paramount importance for adequate national nutrition; and

WHEREAS, the Board believes that the previously contemplated betterment of enrichment standards and the extension of enrichment to the entire white bread and flour supply of the nation are objectives which should be pursued with increased diligence because of the difficulties of procurement of foods, processing equipment and other industrial food supplies,

BE IT RESOLVED that the Food and Nutrition Board favors:

1. Immediate compulsory enrichment of all family flour.

2. Amendment of Food Adminstration Order No. 1 to require minimum levels of thiamine, niacin (nicotinic acid or nicotinamide) and iron in enriched bread to levels recommended at the bread hearings of July-August, 1941; namely, thiamine 1.1 milligrams, niacin 10 milligrams and iron 8 milligrams per pound of bread.

3. Adjustment of the minimum levels of thiamine, niacin and iron in enriched flour to conform to testimony given at the bread hearings of July-August, 1941; namely, thiamine 2 milligrams, niacin 15 milligrams and iron 12 milligrams per pound of flour, these requirements being within the range of levels specified in the regulations defining enriched flour under the Food, Drug and Cosmetic Act.

4. Early inclusion of riboflavin as a required ingredient of enriched flour in the minimum amount of 0.6 milligrams per pound of enriched flour, said amount to be increased to 1.2 milligrams per pound as soon as the available supply of riboflavin permits, and at that time 0.7 milligram of riboflavin be required as a minimum for enriched bread.

5. The extension of enrichment to corn meal and grits in harmony with the enrichment program as soon as proper standards and techniques can be formulated.

BE IT FURTHER RESOLVED that, at the discretion of the Chairman of the Board, a copy of this resolution be sent to the proper federal agencies.

BE IT RESOLVED, in conformity with action taken by the Food and Nutrition Board of the National Research Council at its meeting January 16, 1943, relating to enrichment of flour, bread, corn meal and grits; also, in conformity with past expressions of this Board relating to desirable improvement of American diets, that every effort be made to secure priorities to enable manufacturers of grits to purchase machinery and equipment for enrichment of grits by addition of specified amounts of thiamine, niacin, and iron.

The action of the Board of January 16, 1943, involved adoption of a resolution which contained the following paragraph:

> "The extension of enrichment of corn meal and grits in harmony with the enrichment program as soon as proper standards and techniques can be formulated."

The manufacturers of grits in the United States are limited in number to 30 mills, located in Southern states. The machinery which would be required for enriching all grits is limited to designs already fabricated or easily altered. The equipment allowed to any one mill could be limited as follows:

Galvanized sheet metal	300 pounds
Blenders and feeders	3 units
Total Cost F.O.B.	$750.00

. . . . .

BE IT FURTHER RESOLVED, that this action of the Executive Committee of the Food and Nutrition Board, together with the information relating to equipment and material required, be forwarded to the appropriate federal agencies and to the Chairman of the State Nutrition Committee of South Carolina.

March 5-6, 1943

The Board approved the selection of Drs. Jolliffe, Sherman, Sherwood, Stiebeling or Phipard, Wilder, Williams, and Mr. Patterson as witnesses; and the following figures in milligrams per pound for enrichment levels for flour and bread:

	Minima Per Pound	
	For Flour *mg.*	For Bread *mg.*
Thiamine	2.0	1.1
Niacin	16.0	10.0
Riboflavin	1.2	0.7
Iron	13.0	8.0

In all cases the maxima are to be twice the minima.

. . . . . .

RESOLUTION concerning nutritional enrichment of corn products

WHEREAS, the Food and Nutrition Board of the National Research Council is of the opinion that it would be desirable to have the levels for enrichment of corn products identical with those for enriched flour, and to include riboflavin as a required ingredient;

WHEREAS, the Board recognizes the difficulties of inaugurating and maintaining corn products enrichment and believes that in the interest of facilitating the introduction of this much needed reform a simplified formula may prove necessary:

BE IT RESOLVED, for the guidance of the Cereal Committee, that the Board favors the standard indicated below, to have effect for at least one year, provided that such a standard shall be found consistent with maintaining the legal status of definitions for enriched flour, enriched bread, and enriched corn products:

	Proposed standard mgs. per pound	
	Minimum	Maximum
Thiamine	1.5	3.0
Niacin	16.0	32.0
Iron (Fe)	13.0	26.0

FURTHER, that the immediate enrichment of all corn grits and degerminated corn meal is particularly desirable. Adopted.

. . . . . .

BE IT RESOLVED that, in the light of present knowledge, the Food and Nutrition Board of the National Research Council reaffirms its decision that the fortification of all oleomargarine intended for table use, as provided in the regulations of the Food and Drug Administration, would be in the interest of improved nutrition of the American people.

April 14-15, 1943

COMMITTEE ON CEREALS: (Summary of Report)

Dr. Williams, Chairman, explained that the activities of his Committee have centered largely around the forthcoming Hearings on enriched flour and bread, to begin on Monday, April 19. The purpose of the Hearings is (1) to put into effect the testimony of July and August, 1941, concerning bread; (2) to reconcile the regulations regarding enriched flour with later developments and increased knowledge about enriched bread and (3) to make a short record of testimony which can be quickly reviewed in order to facilitate the early promulgation of an order by the Office of Distribution (War Food Administration) to cover the findings of these Hearings.

The Office of Distribution was preparing an Order regarding flour, which it hopes to make consistent with its Order No. 1, issued in December, 1942, regarding bread, both orders to be as far as possible consistent with the Food and Drug Administration's permanent regulations on enriched bread and enriched flour.

The question of the addition of calcium to enriched flour and bread was thoroughly discussed by the Board. Consideration was given to the food habits of the South, where 80 per cent of the flour consumed is either self-rising or phosphated, both of which contain added calcium, and to the fact that family flour in the North and West goes largely into areas where increased milk consumption reduces the calcium deficiency. The problem of calcium fortification in Great Britain, and the Product "Creta Preparata" which was developed to meet the requirements, were explained by Dr. Drummond, Scientific Adviser to the Ministry of Food, London. Cognizance was taken of the prevalence of calcium deficiency in the United States and the probable effect of an attempt to make mandatory the addition of calcium to bread and flour.

The following resolution was adopted:

April 14-15, 1943

Resolution Recommending Continuation of Optional Addition of Calcium to Enriched Flour and Enriched Bread

BE IT RESOLVED that the Food and Nutrition Board of the National Research Council approved the continuation of the *optional addition* of calcium to flour and bread in amounts per pound of 0.3 gm. minimum and 1.2 gms. maximum. Adopted.

. . . . .

WHEREAS, the present policy of recommended minimum and maximum levels for addition of nutrients to flour and bread has in some cases led to undesirable competitive advertising,

BE IT RESOLVED that the Food and Nutrition Board of the National Research Council recommends that:

> If compatible with the Food, Drug and Cosmetic Act, only minimum requirements for thiamine, niacin, riboflavin, and iron be prescribed for enriched bread and enriched flour and that no claims for vitamin or mineral content in excess of the minima be permitted, and that the present recommended minima and maxima for vitamin D and calcium be maintained.

June 14-15, 1943

MOVED AND ADOPTED that this meeting go on record to the effect that the Federal Security Agency and its Food and Drug Administration hold an early hearing looking toward the establishment at the earliest possible moment of definitions and standards of identity of corn products and enriched corn products.

August 31, 1943

The Food and Nutrition Board of the National Research Council commends to the attention of laboratories of the chemical and cereal industries and to those of universities and experiment stations, the desirability of developing insoluble salts or derivatives of thiamine, riboflavin and niacin, capable of being fixed upon the surfaces of cereal particles in physiologically active form and in a manner to avoid loss by rinsing. Such developments would be of peculiar value in the enrichment of white rice and corn grits. Adopted.

December 10-11, 1943

Resolution Regarding Compulsory Enrichment of Family Flour

The Executive Committee of the Food and Nutrition Board of the National Research Council respectfully urges upon the War Food Administration the importance of immediate issuance of an order requiring the enrichment of white flour for use in homes and institutions in addition to that which is now required to be enriched in bread form by Food Distribution Order No. 1 and subsequent amendments thereto.

The following considerations are deemed to be highly significant in this connection:

1. The existence of Food Distribution Order No. 1 affirms in principle the desirability of enrichment of white flour products, but failure to take similar action regarding family and institution flour implies indifference to the fundamental significance of enrichment of bread.

2. The fact that homemade biscuit is the most popular form of bread in large areas of the South requires that equal consideration be given to family flour as to bakery bread. Otherwise Food Distribution Order No. 1 involves a discrimination against the South. The importance of this point is accentuated by the fact that voluntary enrichment of white flours, especially those of cheaper grades, has been less successful in the South than in any other section of the country. This is partly due to the fact that small millers supply a larger proportion of family flour in the South than in other sections and it has been more difficult to extend enrichment practice to the large numbers of small millers than to the small number of large millers who produce the greater part of the total volume of flour.

3. Hearings on enrichment of flour were held by the Food Distribution Administration in July 1943 at which time the testimony, although divergent as to application of enrichment in the flour mill versus the bakery, was unanimously favorable to the action now sought. Failure to act in accordance with the general tenor of that testimony has given rise to a conviction among many millers that the government as a whole has only a half-hearted interest in enrichment of bread and flour. If this feeling continues to grow it may well go far to destroy what has already been accomplished by voluntary action under the stimulus of the National Nutrition Program. Several large millers are reported to be considering the abandonment of enrichment if the order requiring enrichment of white flour generally is not forthcoming by January 1, 1944. The tendency to such thinking has been increased by the modification of the enrichment formula which went into effect October 1, 1943, and which adds major increments to the costs of enrichment because of the addition of riboflavin as a required ingredient.

4. The War Food Administration should not attach undue weight to the success to date of the voluntary program of enrichment of flour as compared with the probability of success in enforcing orders of the type of F.D.A. Order No. 1 because (a) there is no assurance of a continuation of the success of the voluntary program under a governmental policy which appears inconsistent and half-hearted, and (b) the success of the voluntary program has been least in the area of greatest need, namely the low-income groups of the South. It is deemed certain that a consistent policy throughout the bread and flour field will greatly aid in promoting enforcement of orders covering both bread and flour. The existence of such an order covering flour will encourage complying firms to put pressure for compliance on competitors who, less responsive in their regard for the public health, have not complied with the voluntary program.

In the interests of satisfactory distribution of the nutrients provided by enriched flour and all that this implies for the successful prosecution of the war there is needed an order requiring that all family flour and flour sold to institutions be enriched with a minimum of delay. Adopted.

January 28-29, 1944

Recommendation Urging Issuance of a Standard for Unpolished Rice

RESOLVED that the Food and Nutrition Board of the National Research Council regards the promulgation of a standard for unpolished rice as a useful measure for the conservation of food supply during the war emergency because avoidance of polishing increases the yield of rice and improves the nutritional value of the product.

FURTHER, that a copy of this resolution be transmitted to the Civilian Food Requirements Branch, Office of Distribution, of the War Food Administration. Adopted.

September 8, 1944

Resolution Concerning

Use of Enriched Flour and Bread by Hotels and Restaurants
Adopted by the Food and Nutrition Board

The Food and Nutrition Board of the National Research Council, in conjunction with the milling and baking industries of the United States, has endorsed and promoted since 1940 the enrichment of flour and bread with iron and with three of the vitamins native to that type of product. These nutrients are among the most widely needed for the betterment of the nutrition of large elements of our population.

Great success has been achieved through voluntary compliance with this program on the part of bakers and millers so that by January 1, 1943, it was estimated that about 70 per cent of the white loaf bread and an equal proportion of the white family flour was enriched. Since January 18, 1943, the War Food Administration has required the enrichment of all white bread made by commercial bakeries and beginning on May 1, 1944, white rolls also were brought under the order.

In order to secure the benefits of enrichment permanently for the people of the country the Food and Nutrition Board now renews its plea for full scale adoption of enrichment by all agencies which supply white flour and bread to the public. Among the agencies which can render very valuable service to the universal and permanent adoption of enrichment are the hotels, restaurants and dining-car services of the country. By the exclusive use of enriched flour in breadmaking or by enrichment at the dough stage and by noting on menus: "All our white bread and rolls are enriched for better nutrition," the matter will be brought prominently to public attention and all-out enrichment will be greatly promoted, with consequent advantage to the public.

The Food and Nutrition Board of the National Research Council solicits such cooperation of all hotels, restaurants and dining-car services and brings to their attention this opportunity to take part in the nationwide nutrition program.

. . . . .

RECOMMENDED DIETARY ALLOWANCES *

Food and Nutrition Board, National Research Council

	Calories	Protein grams	Calcium grams	Iron mg.	Vitamin A*** I. U.	Thiamin (B_1) mg.**	Riboflavin mg.	Niacin (Nicotinic acid) mg.	Ascorbic acid mg.**	Vitamin D I.U.
Man (70 Kg.)										
Sedentary	2500	....	....	....	....	1.5	2.2	15	....	....
Moderately active	3000	70	0.8	12	5000	1.8	2.7	18	75	†††
Very active	4500	....	....	....	....	2.3	3.3	23	....	....
Woman (56 Kg.)										
Sedentary	2100	....	....	....	....	1.2	1.8	12	....	....
Moderately active	2500	60	0.8	12	5000	1.5	2.2	15	70	†††
Very active	3000	....	....	....	....	1.8	2.7	18	....	....
Pregnancy (latter half)	2500	85	1.5	15	6000	1.8	2.5	18	100	400 to 800
Lactation	3000	100	2.0	15	8000	2.3	3.0	23	150	400 to 800
Children up to 12 years:										
Under 1 year†	100/Kg.	3 to 4/Kg.	1.0	6	1500	0.4	0.6	4	30	400 to 800
1–3 years††	1200	40	1.0	7	2000	0.6	0.9	6	35	†††
4–6 years	1600	50	1.0	8	2500	0.8	1.2	8	50	....
7–9 years	2000	60	1.0	10	3500	1.0	1.5	10	60	....
10–12 years	2500	70	1.2	12	4500	1.2	1.8	12	75	....
Children over 12 years:										
Girls, 13–15 years	2800	80	1.3	15	5000	1.4	2.0	14	80	†††
16–20 years	2400	75	1.0	15	5000	1.2	1.8	12	80	....
Boys, 13–15 years	3200	85	1.4	15	5000	1.6	2.4	16	90	†††
16–20 years	3800	100	1.4	15	6000	2.0	3.0	20	100	....

*Tentative goal toward which to aim in planning practical dietaries; can be met by a good diet of natural foods. Such a diet will also provide other minerals and vitamins, the requirements for which are less well known.

**1 mg. thiamin equals 333 I.U.; 1 mg. ascorbic acid equals 20 I.U.

***Requirements may be less if provided as vitamin A; greater if provided chiefly as the pro-vitamin carotene.

†Needs of infants increase from month to month. The amounts given are for approximately 6–8 months. The amounts of protein and calcium needed are less if derived from human milk.

††Allowances are based on needs for the middle year in each group (as 2, 5, 8, etc.) and for moderate activity.

†††Vitamin D is undoubtedly necessary for older children and adults. When not available from sunshine, it should be provided probably up to the minimum amounts recommended for infants.

Further Recommendations, Adopted 1942:

The requirement for *iodine* is small; probably about 0.002 to 0.004 milligram a day for each kilogram of body weight. This amounts to about 0.15 to 0.30 milligram daily for the adult. This need is easily met by the regular use of iodized salt; its use is especially important in adolescence and pregnancy.

The requirement for *copper* for adults is in the neighborhood of 1.0 to 2.0 milligrams a day. Infants and children require approximately 0.05 per kilogram of body weight. The requirement for copper is approximately one-tenth of that for iron.

The requirement for *vitamin K* is usually satisfied by any good diet. Special consideration needs to be given to newborn infants. Physicians commonly give vitamin K either to the mother before delivery or to the infant immediately after birth.

APPENDIX D

ACTIONS OF MILLERS' NATIONAL FEDERATION

January 29, 1941.

THE ENRICHED FLOUR PROGRAM

(Statement issued to Press Associations by Millers' National Federation)

The wheat flour milling industry of the United States, through the Millers' National Federation, today pledged its wholehearted support to the program announced by Dr. Russell M. Wilder, chairman, Committee on Food and Nutrition of the National Research Council, for the production of enriched wheat flour containing nutritive vitamins and minerals essential to the maintenance of good health.

The milling industry has cooperated with Dr. Wilder and his associate nutritionists in the development of the program and is prepared to continue that cooperation in the production, promotion, and marketing of the new flour. In addition, the millers have been working closely with the baking industry through the officers and members of the American Bakers Association, and these two great basic food industries are preparing themselves as rapidly as possible to produce flour and bread enriched with vitamins and minerals.

Actual production of the new flour has not yet been undertaken by the industry. Millers have been awaiting the promulgation by the Food and Drug Administration of a standard under the provisions of the Food, Drug and Cosmetic Act. In addition, a great many practical and technical problems connected with the production of the new flour have to be solved by members of the industry.

However, in view of the urgent desire of nutritionists and public health authorities generally to have this product made available at the earliest possible date, the Millers' National Federation, in cooperation with the Food and Drug Administration, has developed a procedure under which the industry may proceed as soon as possible to the production of the new flour in advance of the promulgation of an official standard. Instructions as to how the new flour may be produced, labeled, and marketed, in accordance with the provisions of the Food and Drug Act, have been prepared by the Federation and these instructions are being sent out to millers today.

It is expected the industry will begin producing the new flour just as quickly as possible. However, of necessity it will be several weeks before the flour is on the retailer's shelf and available to the consumer. The flour as well as the bread will be identified as "Enriched Flour" and "Enriched Bread."

The milling industry regards the opportunity to produce and make available to consumers a flour enriched with vitamins and minerals as a high privilege. Flour and bread through the ages have been regarded as the staff of life, and at all times the industry has been sensitive to consumer desires and requirements, and in the light of the best technical and scientific data has produced wholesome and nutritious products to fill those needs and requirements. In developing and producing the new flour the industry is continuing its march of progress and utilizing for the benefit of the consumers the most modern scientific and nutritional discoveries.

RESOLUTION ADOPTED AT ANNUAL MEETING

Chicago, April 29-30, 1942

The wheat flour milling industry through the Millers' National Federation reaffirms its endorsement and support of the National Nutrition Program sponsored by the federal government and related agencies. The production and promotion of enriched flour is an important part of that program. The milling industry pledges its continued cooperation in making this nutritionally desirable food available in increasing quantities.

In the interest of improved nutrition, good health and the general welfare, the Millers'

National Federation recommends to the members of the industry the enrichment of all family flour.

. . . . .

ENRICHED FLOUR

Published by

Wheat Flour Institute, 309 West Jackson Boulevard, Chicago, Illinois.

Special Series No. 10

May 22, 1941.

NUTRITION PROGRAM BROADCASTS TO START JUNE 13

Beginning June 13, the National Broadcasting Company is putting on a series of broadcasts on the national nutrition program, and of course enriched flour will come in for its full share of attention in the course of these broadcasts. Arrangements for the series have just been completed by Paul Cornell, along the line announced in preliminary fashion at last week's convention.

The nutrition broadcasts will be sponsored by the Women's National Emergency Committee, made up of 28 leaders in women's clubs, organizations and women's magazines throughout the United States. Public announcement of this project will be made within a few days by the committee.

The nutrition broadcasts will be on the Red Network, which is generally regarded as the best setup in the radio field, and the first is to be heard on Friday evening, June 13, at 10:30 eastern daylight time (9:30 eastern standard time, 8:30 central standard, 7:30 Mountain standard, 6:30 Pacific standard). The series will continue for thirteen weeks.

NBC is contributing the time for the nutrition broadcasts, amounting at commercial rates to well over $200,000 for the thirteen half-hour programs in the series. The only cost to the industry is that of program-building for the different broadcasts, and that will be paid for out of the fund set aside in March by the milling and baking industries through the Wheat Flour Institute and the American Institute of Baking.

COPIES OF "20 QUESTIONS" BOOKLET: We are having a great many inquiries for copies of the new pamphlet, "Twenty Questions and Answers on Enriched Flour and Enriched Bread." This is a government publication, and while copies are not available as yet we hope to obtain enough to send one each to our members within a few days.

COPIES OF WASHINGTON ADVERTISEMENT: Those who would be interested in obtaining mats in newspaper page size of the advertisement, "The Birthday of a New World," which is appearing in the Washington newspapers early next week, and a copy of which in reduced size accompanied the May 20 "Hook-Up", should apply to the American Bakers Association, 1135 Fullerton Ave., Chicago.

APPENDIX E

ACTIONS OF THE BAKING INDUSTRY ORGANIZATIONS

1. American Bakers Convention, Chicago, October 13-16, 1940, held Round Table Discussion "Vitamin Information Please."
2. Directors of American Institute of Baking, January 22, 1941, passed following resolution:

   "The Board of Directors of the American Institute of Baking, recognizing the importance of and the need for improvements in our national nutrition, both as a defense measure and as a permanent contribution to national health, hereby pledges the resources of this scientific and educational agency of the American Baking Industry to this end, and particularly in helping to bring about the more general availability of nourishing breads enriched in vitamins and minerals in accordance with government standards."
3. American Bakers Association forms Committee to advise the industry on bread enrichment, January 23, 1941.
4. Press Release January 29, 1941 by American Bakers Association.

   "WASHINGTON, January 29: Early and Nation-wide availability of breads containing increased vitamins and food-minerals was indicated today by the American Bakers Association, in a statement pledging full support to the program announced by Dr. Russell M. Wilder, Chairman of the National Research Council's Committee on Food and Nutrition.

   "The nutritional program, intended both as a defense measure and as a permanent contribution to national health, includes the production and promotion of 'enriched' breads high in vitamins and minerals needed in the diet.

   "The bakers gave enthusiastic approval to the plan calling for ultimate adoption of Government standards for these breads.

   "Vitamin B_1 and the food-minerals calcium and phosphorus, the bakers revealed, already are present in liberal quantities in most breads, because of the customary use in bread of milk solids rich in these food elements.

   "Several methods for raising the vitamin and food-mineral content of bread will be available to bakers, including use of an 'enriched' flour, which will be provided and standardized by the Flour Milling Industry, use of yeasts with high vitamin and mineral content, and direct incorporation of the vitamins and minerals in the baking process.

   "The Baking Industry, its representatives said, will not delay the program pending Government adoption of standards, but will attempt to make the new bread available everywhere as quickly as possible, in conformity with tentative requirements and procedures agreed on with the National Research Council and Government officials.

   "The bakery representatives promised the Association's resources and the laboratories and personnel of the American Institute of Baking for the handling of technical and production problems in connection with the new breads, and to inform and marshal participation of the Nation's 30,000 bakers, who produce 12 billion pounds of baked foods yearly.

   " 'Bread offers the ideal medium for providing the consumer with increased amounts of these essential vitamins and minerals,' L. J. Schumaker of Philadelphia, Association President, said following a conference with Dr. Wilder and other representatives of the National Research Council, Government and wheat flour milling industry. 'Bread, always the Staff of Life, will become doubly so. We consider this the Baking Industry's greatest opportunity in its service to the American consumer.'

   " 'We desire to demonstrate,' Schumaker said, 'that by cooperation of Government, Science and Industry, a constructive program can be brought to the consumer with a Nation-wide coverage,—with a minimum of delay.' "

5. Directors of American Institute of Baking recommended February 17, 1941 that "* * * the American Bakers Association, jointly with the Millers' National Federation and Associated Retail Bakers of America, call an industry-wide conference at as early a date as can be arranged, to which would be invited all members of both the Baking and Milling industries, and other interested Allied Trades—

   A. To thoroughly acquaint members of these industries with the National Nutrition Program proposed by NRC and governmental departments.
   B. To coordinate this program.
   C. To urge the production and orderly introduction to the public through approved promotional and merchandising methods of "enriched" bread and flour.

   Money was provided toward making services of Mr. Paul Cornell and Mrs. Gerry Kirk available to Dr. Helen Mitchell and Dr. M. L. Wilson and for use on a "Listen America" program on radio in June. Radio station provided time; bakers' money was used to provide music and any talent that was paid for."

6. Board of Governors of American Bakers Association adopted following resolution February, 1941:

   "On motion made and duly seconded, it was voted that the statement 'exhibit A' be adopted as the recommendation in 'substance' and in principle of the Governors of the A.B.A.

   CARRIED."

EXHIBIT A

A STATEMENT ON THE MATTER OF VITAMINS AND MINERALS IN THE DIET

"The American Bakers Association is confident that it expresses here the views of the Baking Industry with respect to vitamins and minerals in the diet.

"The Baking Industry is ready, willing and anxious to cooperate with the Government, medical associations and scientific societies in contributing to the improvement of the American diet in conformity with the newer knowledge of nutrition.

"In order to expedite action and provide a progressive program we suggest the following, as applied to the Baking Industry—

(1.) We suggest that a standard be established for a bread or breads high in vitamin and mineral content, with desirable minimum and maximum levels, under an appropriate name.

(2.) We suggest that the Government provide the Industry with an approved list of ingredients and methods by which these elements may be included in the bread.

(3.) We suggest that a label be approved which will serve to identify the product and protect the consumer.

(4.) We suggest that this activity be handled through established bakers' associations.

In making these recommendations we are guided by the following—

a) We desire to protect the consumer against exploitation and ourselves against over-zealous competitors.

b) We desire to follow the example of the medical profession and make (through the medium of our Institute) this newer knowledge of nutrition and methods open to all members of the Industry on the same basis.

c) We desire to demonstrate that by cooperation of Government, Science and Industry a constructive program can be brought to the consumer with a nation-wide coverage—with a minimum of delay.

"To further this program we offer the entire staff, the members and committees of the American Bakers Association.

"In the discussion that followed it was stated that such governmental agencies as the American Public Health Service might print pamphlets to get nutrition information into the homes,—through the Department of Agriculture Extension Workers, etc."

7. Industry Conference on Enriched Bread and Flour, Chicago, March 5, 1941, sponsored by American Bakers Association, Associated Retail Bakers of America and Millers' National Federation.
8. Enriched Bread Session at 44th Annual Convention, American Bakers Association, Boston, October 13, 1941.
9. Board of Governors, American Bakers Association, January 23, 1942, adopted the following resolution:

   "The Board of Governors of American Bakers Association join the Directors of the American Institute of Baking in emphatically expressing their firm belief in the future of enriched bread (enriched with vitamins and minerals according to the recommendation of the National Research Council, and under such standards as will be promulgated by the Food and Drug Administration);

   "And, further, the Board of Governors expresses its belief that enriched bread should be made more generally available now, particularly as an important factor to national health and well being during this war period and the time immediately following, and as a permanent contribution to National welfare."

10. Bakers War Conference, Chicago, October 1942, adopted the following resolution:

    "RESOLVED: The food value of bread must and will be maintained,—come what may.

    By bread we mean breadstuffs,—bread, cake, pie, baked foods of all kinds.

    Despite any problems of supplies, manpower or facilities, we firmly resolve that the bread for the people and for the armed forces at home shall continue to be good bread—the finest in the world.

    We recognize the responsibility of bread as the foundation of the diet—that regardless of shortages, rationing or changes in other foods, bread must not change, unless it be for the better.

    Because bread is the food of the PEOPLE, because it is universally consumed, because it is the means by which every member of the population can be assured his available share of food values that are scarce, we resolve that these food values shall not be taken out of the bread.

    We will not only maintain but improve the nutritive quality of bread. As an immediate and specific step, we recommend universal compliance with the request of the U. S. Office of Defense Health and Welfare Services and the National Research Council that ALL white bread be 'enriched' with vitamins and iron.

    We further recommend to the American Institute of Baking and the American Society of Bakery Engineers that they establish a joint committee to confer and cooperate with the Food and Nutrition Board of the National Research Council and the U. S. Department of Agriculture, to assure an adequate supply of the ingredients needed to maintain the nutritional values of bread.

    No shortage, no regulations, no handicap, no obstacle, will distract us from this fundamental resolve and aim—to preserve and enhance the goodness, to assure the adequate supply, of our country's bread."

11. Board of Governors of American Bakers Association took the following actions January 22, 1943:

    Authorized officers to prepare a communication to U. S. Department of Agriculture approving the recommendations of the Food and Nutrition Board of the National Research Council with respect to thiamine, niacin, iron and riboflavin minimum-maximum content provisions for enriched white bread, provided that, in their opinion, these recommendations were in keeping with the possibility of compliance by the Baking Industry, and provided that, if necessary, the Office of Price Administration would permit the necessary relief in price ceilings because of any increased cost due to this increase in nutritional standards.

    It was also resolved that: "The American Bakers Association, on behalf of the

Baking Industry as an integral part of the agricultural economy converting farm products and distributing them in nutritious form, extend wholehearted cooperation to the United States Department of Agriculture on the common objective of helping to maintain an adequate supply of food for the American consumer and for our armed forces and allies abroad. That the American Bakers Association expresses appreciation of the reasonable attitude of the Food Distribution Administration within the Department and its evident determination to make its policies and regulations practicable and to formulate them with the benefit of information and suggestions secured from competent persons familiar with the operations affected. That the American Bakers Association makes completely available to the Department the services of its staff and facilities in the interest of the National welfare."

12. American Bakers Association, May 1, 1944, released to trade press:

Copy of a letter from Ralph D. Ward, Chairman, Board of Governors, to Dr. Gunderson, reporting that at the meeting of the Board of Governors of the American Bakers Association held in Chicago, March 21, 1944, at which Dr. R. R. Williams was an invited guest, it was unanimously voted that the American Bakers Association wholeheartedly continue to support the vitamin and mineral enrichment program, and to that end each Governor assumed a personal obligation for the success of the enrichment program in his territory.

APPENDIX F

RESOLUTION PASSED BY THE AMERICAN PUBLIC HEALTH ASSOCIATION

The following resolution was passed October 4, 1944, by the American Public Health Association at its annual meeting:

CONTINUED ENRICHMENT OF STAPLE FOODS

WHEREAS, the order of the War Food Administrator making compulsory the enrichment of white flour and rolls, the legislative action of certain states with regard to enrichment of certain staple foodstuffs, and the voluntary action of many food industries have resulted in an improvement in the national dietary with respect to several highly essential nutrient elements, and

WHEREAS, this enrichment in staple low cost foods has been of proportionately greater benefit to the economic groups whose diet is most in need of betterment, and

WHEREAS, the Federal order for the enrichment of white bread and rolls will terminate with the passing of the war emergency, be it

RESOLVED that the American Public Health Association goes on record as favoring appropriate state and federal action to perpetuate the benefits that have accrued to the national dietary through enrichment of staple foods in accordance with the recommendations of the National Research Council.

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